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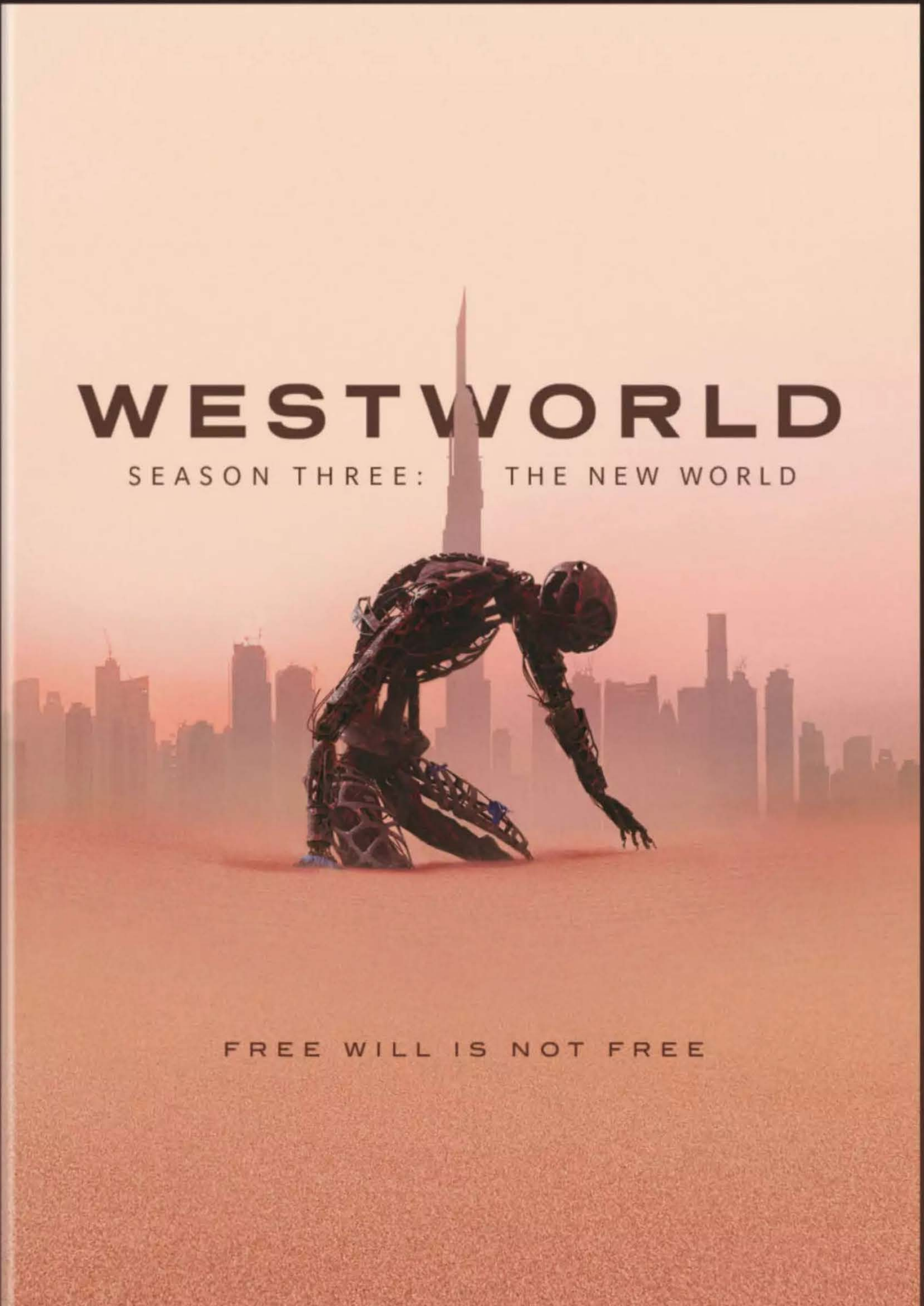
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Staff Writer: Christian Guyton
Contributing Writers: Dave Alcock, Mike Bedford, Jonni Bidwell, Ian Evenden, Jeremy Laird, Chris Lloyd, Nick Peers, Les Pounder, Jarred Walton
Copy Editor: James Price
Editor Emeritus: Andrew Sanchez

ART
Art Editor: Fraser McDermott
Photography: Phil Barker, Olly Curtis, Neil Godwin, Dave Alcock
Cover Photo Credits: Ubuntu, Future plc

BUSINESS
US Marketing & Strategic Partnerships: Stacy Gaines, stacy.gaines@futurenet.com
US Chief Revenue Officer: Mike Peralta mike.peralta@futurenet.com
East Coast Account Director: Brandie Rushing, brandie.rushing@futurenet.com
East Coast Account Director: Michael Plump, michael.plump@futurenet.com
East Coast Account Director: Victoria Sanders, victoria.sanders@futurenet.com
East Coast Account Director: Melissa Planty, melissa.planty@futurenet.com
East Coast Account Director: Elizabeth Fleischman, elizabeth.fleischman@futurenet.com
West Coast Account Director: Austin Park, austin.park@futurenet.com
West Coast Account Director: Jack McAuliffe, jack.mcauliffe@futurenet.com

Director, Client Services: Tracy Lam, tracy.lam@futurenet.com

PRODUCTION
Head of Production: Mark Constance
Production Manager: Vivienne Calvert
Project Manager: Clare Scott
Production Assistant: Emily Wood

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Zak Storey

THE GOOD & THE BAD

WELL, IT'S BEEN ONE heck of a month for us here at Future, that's for sure. I have some good news, and a bit of bad news to share with you all. Happily, however, the good news far outweighs the bad—well sort of. So let's start with the worst bit first.

Future's transition over to its new subscription platform (www.magazinesdirect.com) has been a bit problem-fraught, which is perhaps a nice way of putting it. We've had a lot of issues with you guys not receiving your latest copies. Rest assured I'm forwarding on these complaints internally as best I can, but the best thing you can do is email the boys and girls at **help@magazinesdirect.com**. They have quite the backlog of tickets right now, due to the move over to the new platform, especially from us US publications, struggling due to the ongoing coronavirus pandemic and issues on the ground level with USPS. However, I've been assured that they've almost doubled the customer service team to get through the tickets as fast as possible. So if you're still having trouble getting your physical issues, that's the best way to get it resolved.

Now that's out of the way, on to the good news. Last issue I spoke about how for our Holiday edition we'll be going back up to our pre-lockdown budget and page count. I can now confirm that that's not actually true. Yep, we'll still be going back up to our 100 pages an issue, but with one slight exception. Thanks to my perpetual moaning at management, and some financial wizardry (which I'm still convinced is a mistake, but I'm not about to look a gift-accountant in the mouth) we've had our budget increased by 35 percent in comparison to our pre-lockdown figure. That is, honestly, huge. In fact, with it, I've given all of our freelancers a pay rise, invited a lot of the regular folk back, and yet am still struggling to spend all those bucks. It's a nice feeling, for sure, and because of that we're actually changing up the mag a bit as well next issue to get the most out of it. That means more in-depth features and deep dives across both software and builds, more advanced tutorials and knowledgeable writers, more columns from regular favorites, and more reviews too. In fact we're already working on the next issue as I write this, and it looks like a seriously kick-ass edition of *Maximum PC*, I'm excited to see what you all think of it.

Anyway, enough of that. What about this issue? Well, December's edition ain't no slouch either, and with Nvidia launching its latest RTX 3000-series graphics cards, there's a lot to cover. We of course have a review of Nvidia's brand new RTX 3080 GPU, a deep dive on the Ampere architecture, an in-depth look at building the perfect living room gaming PC, including streaming alternatives, a quick stroll into the latest version of Ubuntu, and some seriously epic reviews, columns, and more too—including me crashing cars just a little bit.

As always, stay safe out there! And I'll see you all next time.

Zak Storey

Zak Storey is Maximum PC's *editor and long-time staff member. He's been building PCs since he was 10, and is more than capable of butting heads with the biggest names in tech.*

↘ submit your questions to: comments@maximumpc.com

THE NEWS

Big Navi Lands

With AMD's new launch, Nvidia has a serious rival at last

AMD'S NEW RDNA 2 graphics cards—unofficially known as "Big Navi"—are finally ready. At the heart is a whole new 7nm GPU architecture. AMD has been playing second fiddle to Nvidia for a while now, but the company is confident that this is the chip to change that.

Initially we will get three new cards using the new GPU: The Radeon RX 6900 XT and 6800 XT using Navi 21 chip, and the 6700 XT using Navi 22. As we write this, the official release is a few days away, but, as usual, there have been numerous leaks. The new cards will carry 5,120, 3,840, and 2,560 Stream processors respectively (80, 60 and 40 Compute Units), backed by 16GB, 12GB, and 6GB of GDDR6 memory. Power consumption is 300W, 200W, and 150W. Clock speeds are unconfirmed but widely quoted as a max boost of 2GHz on all cards, with a base clock of 1.35GHz or 1.5GHz.

The cards have a 256-bit memory bus—not a match for the RTX 3090s 352-bit, or the RTX 3080's 320-bit. However, there's a clever cache system that aims to improve the hit rate—always much better than delving around in the main memory. The RDNA 2 chips have a fatter cache too: Navi 21 carries 8MB of cache, and the Navi 22 sports 6MB. Raw number-crunching puts the new cards generally behind the Ampere-powered Nvidias. An RTX 3090 manages 35.58 TFLOPs of 32-bit floating point, against 20.48 for the RX 6900 XT. There's more to game performance than that though, and the pixel rates for both cards are about the same.

The end result: Epic Games has a stunning demo of the Unreal 5 engine running on RDNA 2.

While there has been a lot of speculation over RDNA 2, AMD itself has been annoyingly quiet, which has led to some questionable speculation. We do know it's a big chip— literally—at around 536 square millimeters, which leaves a lot of room for all that cache. We also know it is going to be tasty; after all this is at the heart of the forthcoming PlayStation 5 and Xbox Series X consoles, with their claims of "uncompromising 4K gaming." We will have to wait for reviews proper on performance (next month folks), but a 6900 XT looks set to give Nvidia's RTX 3080 a run for its money. The new Radeon cards are due for retail launch in November, and AMD is reportedly ready to do this in a big way, with plenty of cards to go around.

Meanwhile, over at Nvidia, the launch of the new Ampere cards has had a few problems. Things weren't helped by the fact that it was almost impossible to buy an RTX 3080, as the limited supply of cards were snapped up by traders using sniping bots. The cards then resurfaced on eBay at inflated prices. The shortages are expected to last into the new year, as Nvidia's CEO Jensen Huang admitted "demand will outstrip all our supply through the year." When people did manage to get their hands on cards, reports started surfacing of rather too many failures. Apparently the cards got distinctly wobbly at high clock rates. Suspicion fell on the types of capacitor fitted. Now the blame has shifted to the drivers, which allowed the clock rate to change too often. Whatever the cause, an updated driver was released that stops the cards being pushed into instability.

Aside from these, the new Ampere-powered cards are undoubtedly powerful, although not quite the world-shakers some had expected. This wasn't helped by Nvidia's initial claims. It's always better to be faster than expected, rather than disappoint by being slower, however fast that actually is. AMD has taken a better line here, being positive without being boastful.

RDNA 2 will give AMD a card that can compete toe to toe with Nvidia's best. It isn't going to be the Nvidia-killer some had hoped, but it can hold its own: A position a Radeon card hasn't managed for a while. If AMD keeps its pricing competitive then we have a real fight on our hands. Matching the RTX 3090 might bring glory, but beating the 3080 and forthcoming 3070 is more important—as it's where most of the sales will be. If some of AMD's Ryzen magic has transferred to the Radeon range then that's going to be good for us. **–CL**

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XBOX FOR $299

NEXT GEN OF CONSOLE GAMING CAN COME CHEAP

WE NOW HAVE THE PRICES for the next generation of consoles. The good news is that they start from $299 for the Xbox Series S. This diminutive, budget version of the Xbox lacks a drive and is less powerful than its big brother, aimed at 1440p gaming and only running 4K using upscaling. It also has more limited backwards compatability. For full 4K gaming and a disk drive, the Xbox Series X will set you back $499, exactly as expected.

Sony has also confirmed its pricing: The PlayStation 5 will also cost $499. The PlayStation 5 Digital Edition will be $399, however. You get exactly the same 4K game machine inside—all you lose is that Blu-ray drive. Microsoft's cheaper digital version is a shrewd move. The console market is a notoriously price-sensitive one. 100 bucks one way or the other perhaps isn't that much, but it counts for a lot. The two consoles haven't launched yet, but round one looks to have gone Microsoft's way. **–CL**

NVIDIA KILLS SLI

Game over for multiple graphics cards

NVIDIA IS PULLING THE PLUG on SLI—Scalable Link Interface. SLI is implemented in two modes: Implicit via the DirectX driver, and explicit, which is coded into the game. From January next year there will be no new implicit SLI profiles in the GeForce driver for any RTX cards, and all support in future will be limited to explicit only. This is not the end of SLI exactly, but any game that wants to use multiple cards will have to code for it directly. Currently, the only Ampere-powered card with SLI connectors is the RTX 3090, and developing for the tiny number of people with two of these monsters looks unlikely. SLI has been useful but never particularly popular, and has had its fair share of bugs. It was a good idea that never quite panned out. For now it's better to use one powerful card. **–CL**

Tech Triumphs and Tragedies

A monthly snapshot of what's good and bad in tech

TRIUMPHS

✓ **LAPTOPS GO FOLDING**
The forthcoming Lenovo ThinkPad X1 Fold is the world's first folding PC. The 13.3-inch tablet costs a hefty $2,499.

✓ **WINDOWS WARNINGS**
The latest preview build of Win10 will warn you if your NVMe SSD drive is about to fail.

✓ **XP CODE LEAK**
The source code for Windows XP and Windows Server 2003 is online: Not quite complete but it will compile and run.

TRAGEDIES

✗ **NIKOLA FAKES DEMO**
The electric truck company has admitted to faking a demonstration. The vehicle was actually coasting down a slope.

✗ **APPLE SUES RECYCLER**
Apple's former partner GEEP Canada apparently sold devices it was supposed to recycle.

✗ **INFLATED FIGURES**
TikTok rival Triller boasted of 13 million active users, only to recant when the real figure was alleged to be about 2 million.

ROCKET LAKE VS. ZEN 3

The battle for the king of the desktop rages

IN THE BLUE CORNER we have Rocket Lake. Intel at last moves away from the venerable Skylake-derived microarchitecture and "backports" its newer Willow Cove design (or Cypress Cove if rumors prove true). This will give a useful bump in instructions per cycle of up to 25 percent, although losses in the backporting process may eat into that. This wasn't the original plan, but setbacks in the manufacturing of 10nm chips have left Intel no choice but to stick with 14nm. Speeds should reach 5.3GHz, and there'll be PCIe 4.0 support. It'll also carry the new Xe graphics engine, finally giving Intel something that can make a decent stab at running games.

One disappointment is the core count: Rocket Lake looks likely to top out at eight cores, as excessive heat gets problematic over this. Intel is being tight-lipped about what's coming, but we don't expect anything before next year. Given that the hybrid Alder Lake is due afterwards, we may see a split in the desktop market.

Meanwhile, in the Red corner we have Zen 3, following AMD's excellent 7nm chiplet design. Unlike Zen 2, this is a new microarchitecture, and much work has been done on improving the cache efficiency. We can expect a nice IPC bump of between 10-15 percent, and a power reduction of around 10 percent. Where AMD really scores is the core count: We'll get 16-core versions. The Zen 3 chips will carry a 5000-series name (probably), and early benchmarks on engineering samples look tasty. All varieties of Zen 3 chip (desktop, server, and laptop) should be available before the end of next year.

Things look tough for Intel. Zen 3 will be here first, and will be fast. AMD also looks likely to take the crown of the best single-thread performance (still important in many games and benchmarks). **–CL**

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THE LIST

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1 HYPERX ALLOY CORE RGB $45

It's not mechanical, but this is one of the best membrane gaming keyboards we've seen: Feature-rich and super-quiet, with excellent durability to boot.

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Jarred Walton

TECH TALK

Anatomy Of A GPU Launch: Ampere

GETTING THE STARS to align for a perfect launch is difficult at the best of times. Nvidia's Ampere launch in 2020 didn't even come close. From delays to shortages, price gouging to early driver problems, this could be the worst GPU launch in Nvidia's history. It's not that the product is bad—part of the problem is that it's so good. Hopefully, by the time you read this, things will be in a much better state. Or wait until the new year.

Part of the blame goes to the COVID-19 pandemic, naturally. It's an easy scapegoat, but there's no denying its impact on the technology sector. Events like GDC, GTC, Computex, and more were cancelled or moved online this year, while quarantines and social distancing around the globe caused many product launches to get pushed back. Our expectation going into 2020 was that Ampere would launch in the spring or summer, which obviously didn't happen. But COVID wasn't the only problem.

When the RTX 3080 officially went on sale on September 17, online stores were met with unprecedented demand. Amazon says it saw more traffic than on Black Friday, if you can believe that. Naturally, supplies of the new wonder-GPU were nowhere near sufficient. Every major retail outlet apparently sold out within seconds, and the servers for multiple sites crashed under the load—Nvidia's own storefront went down, as did Newegg and others. When the dust settled, bots managed to procure many of the sales. Nvidia says it manually reviewed every order and canceled those that came from bots, as well as only allowing one GPU per buyer. It still wasn't enough, as the RTX 3090 was basically an encore performance one week later.

Nvidia claims it had as much inventory on hand for the Ampere launch as it did for the Turing launch in 2018, but that overlooks the fact that major shortages occurred at the Turing launch. That's even with the big jump in generational pricing that Turing was packing—remember the $80-$200 RTX 20-series Founders Edition tax? The Ampere launch mostly kept things at Turing levels (other than the $1,500 3090), but with improved performance and equal or lower prices than the outgoing GPUs, it was a double whammy. All of the people still running Pascal GPUs finally have a compelling reason to upgrade. Everyone I know expected demand to be far greater this round, and it was.

Even for those who did get a new GPU, things were still rough. I experienced crashes during testing of multiple third-party cards prior to the launch. This isn't entirely unheard of, particularly with a new architecture and new drivers, but the initial crashing was far more rampant than I can recall seeing on any prior GPU. Factory-overclocked cards were particularly unstable. The good news: Nvidia's 456.55 drivers fixed the crashing issues, about 10 days after the 3080 launch. 10 days of bumpy roads for the few who managed to buy a card isn't the end of the world, but it was one more thing that went wrong.

The RTX 3080 and RTX 3090 launches went poorly; can the RTX 3070 fare any better?

Now we're waiting for the RTX 3070 to launch, along with AMD's RX 6000 series, the PlayStation 5, and the Xbox Series X. I suspect demand will once again far outstrip supply for all of these, but—knock on wood—maybe things will go better than the RTX 3080. Unfortunately, Nvidia's CEO has stated that he expects shortages for Ampere to continue into 2021, so don't hold your breath. Stores may implement better anti-bot protections, but that won't be enough, as scalpers and shopping bots continue to evolve.

My advice: Practice patience. All indications are that Nvidia and its partners aren't intentionally limiting supply; it just takes time to manufacture the GPUs, cards, and even packaging. Speaking of which, there are multiple accounts of stores shipping RTX 30-series cards without packaging, presumably because that part of the supply chain ran into problems. Somewhere down the line, everyone who wants an RTX 3080—or an RX 6900 XT, PlayStation 5, or Xbox Series X—will be able to buy one. And if you're not among the first wave of people to get the latest and greatest hardware, that just means you're less likely to experience the initial teething problems. Let the early adopters do the beta testing; two months down the road, things will inevitably be better.

Jarred Walton has been a PC and gaming enthusiast for over 30 years.

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DOCTOR

THIS MONTH THE DOCTOR TACKLES...

> Blu-ray Ripping
> Display Freezes
> PCIe Lane Query

Newer GPUs will improve Blu-ray ripping performance.

© NVIDIA

Blu-ray Ripping

I am building a new PC to be used to rip a large collection of DVDs and Blu-ray discs, and I would like your thoughts as to which hardware would make the task faster.

I use a software package called Pavtube to do the conversion. The software has an option to speed up the process by enabling Nvidia's CUDA cores on the graphics card. I see when I look at the specs of various Nvidia graphics cards listed on Pavtube's website that there are different numbers of CUDA cores depending on the card—from 1,536 cores (GeForce GTX 1660 TI) all the way up to 4,992 (Tesla K80). Is this important? Would an even newer card—the RTX 2070 Super or RTX 2080 Super—be a better choice?

Finally, would you recommend pairing this with an AMD Ryzen 5 or Ryzen 7 with 32MB of 3200MHz memory and a B450 chipset?

–Marvin Malasky

THE DOCTOR RESPONDS: One word of warning before we continue—Malwarebytes flagged Pavtube as a potential phishing site when we went to test it. If you're happy with the product, then Malwarebytes is probably being over-sensitive. Otherwise, the good news is that Handbrake (https://handbrake.fr) now supports NVENC hardware encoding to h.264 and h.265 formats with compatible graphics cards: Nvidia GTX 1050+ (Pascal version), GTX 1650 (Volta), or GTX/RTX 1660/2060+ (Turing), all running the Nvidia driver 418.81 or later. You'll also need to enable the options via "Tools → Preferences → Video," tick "Allow use of the Nvidia NVENCE Encoders."

The NVENC codec makes a difference to ripping times, but the improvements aren't anywhere near as spectacular in Handbrake as those claimed in Pavtube. The Doc's test machine—X470 chipset, Ryzen 2700, 32GB RAM and Nvidia GTX 1660 SUPER—delivered improvements of between 15-25 percent in encoding times when choosing the NVENC h.264 codec. The more CUDA cores you have, the bigger the difference, but before prioritizing a new graphics card, consider image quality and file size.

The good news is that the newer Turing-based graphics cards do deliver good quality video; previous-generation cards produce visibly inferior movies. However, file sizes are significantly larger with NVENC encodings—up to twice the size. So your choice is simple: Faster encoding times or smaller file sizes.

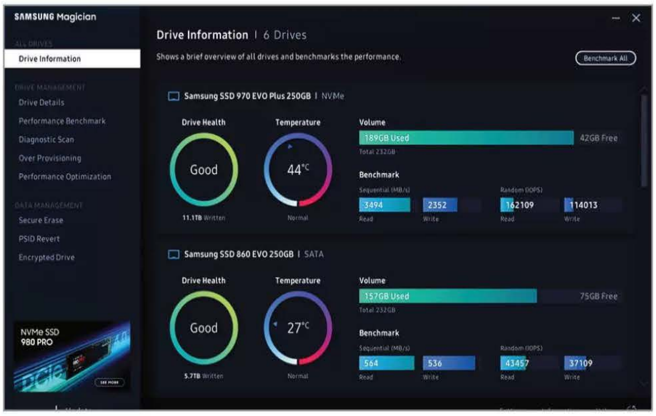
With this in mind, the Doc suggests you focus more on your other components. The B450 chipset and 32GB RAM is a strong base, but choose the Ryzen 7 over the Ryzen 5—the additional cores will do more to reduce ripping times than investing in a higher-end graphics card; the x264 codec will produce smaller files and still be able to encode Full HD movies in around 30 minutes.

Display Freezes

I've got a bizarre issue that started a few months ago that I've been unable to diagnose or resolve. My system freezes randomly, sometimes several times a day, sometimes not for a day or two, but eventually it hits, and my only recourse is to do a hard reset. There are some strange oddities about this I've never seen before. First, when it freezes, the sound continues—whether a game, YouTube video or whatever. The system is locked and unresponsive, but the sound carries on until I finally hit the reset button. I can't find anything in Event Viewer and there is no BSOD or other error given.

Other peculiarities—which may or may not be related—

↘ submit your questions to: doctor@maximumpc.com


SAMSUNG Magician
ALL DRIVES
Drive Information
DRIVE MANAGEMENT
Drive Details
Performance Benchmark
Diagnostic Scan
Over Provisioning
Performance Optimization
DATA MANAGEMENT
Secure Erase
PSID Revert
Encrypted Drive
NVMe SSD 980 PRO
Drive Information | 6 Drives
Shows a brief overview of all drives and benchmarks the performance.
Benchmark All
Samsung SSD 970 EVO Plus 250GB | NVMe
Drive Health
Good
11.1TB Written
Temperature
44°C
Normal
Volume
189GB Used
42GB Free
Total 232GB
Benchmark
Sequential (MB/s)
3494 Read
2352 Write
Random (IOPS)
162109 Read
114013 Write
Samsung SSD 860 EVO 250GB | SATA
Drive Health
Good
5.7TB Written
Temperature
27°C
Normal
Volume
157GB Used
75GB Free
Total 232GB
Benchmark
Sequential (MB/s)
564 Read
536 Write
Random (IOPS)
43457 Read
37109 Write

The PCH really doesn't hurt performance on M.2 drives.

© SAMSUNG

are the fact various settings (RGB lighting settings via Aura; SB Connect 2 for my video card and sound card RGB strip) are lost after the reboot, plus I get random, intermittent sound stutters like a severe hiccup that last a second or two before going away—these seem to be tied to drive access, but I can't tell for sure since they happen so quickly and are gone.

I've recently swapped out the motherboard with an identical model to resolve a separate issue, and I've done an in-place reinstall of Windows. I've tried removing the soundcard and used just on-board sound. All drivers and the BIOS are up to date. Temps are fine according to NZXT CAM. Nothing's helped.

My system specs are: Intel i7 7700K (not currently OC'd), NZXT Kraken X62 AIO, Asus RoG STRIX 1080 Ti, Asus Maximus IX Formula, 32GB G.Skill, five Samsung SSDs (1x960 Pro NVMe 1TB, 1x850 Pro 256GB, 1x860 EVO 2TB, 2x850 EVO 2TB), and a SoundBlasterX Ae-5 all plugged into an Enthoo Evolv (I mention that since I'm using their PWM hub, in case that could be a factor). Any ideas? It's driving me crazy!

–John Meyers

THE DOCTOR RESPONDS: John followed up his email with some more details—one of which was the discovery of numerous "Xvd" entries under Disk Drives in Device Manager. The Xvd entries are virtual drives created by Xbox Game Pass games installed through the MS store, which triggered the realization that the issue began shortly after he first started using Game Pass on Windows. A further look in Event Viewer revealed a host of error entries referring to these drives—some referring to errors during paging operations, and others referring to "surprise" removals.

It seems far too coincidental that these problems aren't related—a good description of what's going on can be found at http://bit.ly/MPCIluminati—this would definitely place the stuttering issues at Game Pass's door, and we suspect the display freezes may also trace back here too.

First, take a full drive image using a tool like Macrium Reflect Free (www.macrium.com/reflectfree.aspx)—this gives you something to roll back to if the next two steps don't work. Step one is to uninstall Game Pass to see if the problem disappears.

If this doesn't resolve the issue, bite the bullet and adopt a nuclear approach to eliminate all potential software problems: Wipe the drive and reinstall Windows from scratch. If the problem goes away, keep taking regular drive images as you restore drivers, software, and so on—if the issue resurfaces, you'll know to focus your troubleshooting efforts on whatever was most recently reintroduced. And if the problem remains after a fresh install, restore the drive image you took, and turn your attention back to the hardware.

One component you've not mentioned troubleshooting is the video card. Given the problems are with your display, it should be your next port of call. Reset any overclocks back to their defaults, and if necessary, remove the card and run from your i7's integrated Intel HD Graphics 630 chipset, instead using the mobo's own HDMI port to hook up your display. If it does, you're looking at a possible driver problem (although the clean Windows install should have fixed that), or a failing graphics card, which will need replacing.

That said, before swapping to a new card, use Open Hardware Monitor (https://openhardwaremonitor.org) to check for voltage and temperature spikes (see issue No 8's column) that might indicate a problem with the PSU or cooling, and run a test with the built-in Windows Memory Diagnostic tool to verify that there's nothing wrong with your RAM.

If none of these suggestions lead anywhere, get back in touch with an update on what you've tried and how it went down, and the Doc will take a fresh look. Including your event viewer logs will also help (open Event Viewer to "Custom Views → Administrative Events"—once they appear, click "Save All Events in Custom View As..." to create an .evtx file, which you should zip up and attach to your email).

PCIe Lane Query

I recently upgraded to the Asus ROG Striz Z390-E gaming motherboard, which I'll be transferring my i7-8086K and RTX 2080 Super into. My question is about the PCIe lanes and the differences between 4x, 8x and 16x. I'm planning to install two NVME M.2 drives—one for the OS, and a second as a game library drive. Can you please explain how these all work together?

–Chris Huebler

THE DOCTOR RESPONDS: PCIe transfers data using serial connections known as lanes. Each lane contains two pairs of wires: One for sending data, the other for receiving it. The serial connection works in a similar way to a network, sending and receiving data in packets through each lane's four wires. The number in 4x, 8x, and 16x PCIe connectors refers to the number of lanes in that PCIe slot (four, eight, and 16 respectively).

The speed of each PCIe slot is further determined by the version of PCIe supported by your motherboard: The Z390-E supports PCIe version 3.0, which means each PCIe 3.0 x4 slot can handle a theoretical maximum data throughput of 32 gigabits per second (4GB/s —gigabytes per second), or 8Gb/s (1GB/s) per lane.

How does this work out in real terms? The Doc's X470 setup has PCIe x4 slots like yours, and his Samsung 970 EVO Plus NVMe drive benchmarks around 3.5 gigabytes per second (read) and 2.4GB/s (write). One of the reasons for this slower speed is because NVME slots transfer data through the chipset via a PCH (Platform Controller Hub) as opposed to the CPU.

Until recently, CPUs were hobbled by the number of PCIe lanes they could handle—your i7-8086K chip supports a maximum of 16 lanes, which is enough to run your GPU at maximum speed, but leaves no room for any other devices. While it's possible to connect other PCIe devices through the CPU, this would force the GPU to run at half-speed to free up eight lanes for elsewhere.

This is why mobos offer two types of PCIe slot: Those that run through the CPU (the Z390-E has two x16 slots for this purpose), and those that run through the PCH (the Z390-E runs an extra x16 slot, plus a x1 slot as well as the two NVMe slots). While PCH-connected slots aren't as fast as those running off the CPU, the performance trade-off is far less than forcing your GPU to run at x8, as evidenced by the Doc's Samsung EVO benchmarks. ⏻

COUCH POTATOES

As new consoles flood the market, we're building a living room gaming machine, with *Christian Guyton*

WITH MICROSOFT AND SONY gearing up for battle, and our living rooms acting as the arena in which the next console war will be fought, the PC is in a strange place. Yes, consoles have their advantages, and we love them dearly (you'll have to pry the Nintendo Switch Lite from our cold, dead hands), but our beloved PCs are only getting better too.

Discrete GPUs are becoming more powerful, and PCs maintain superior flexibility over consoles—we'd like to see an Xbox run the Adobe Creative Suite—and former big exclusives like *Halo* and *Horizon: Zero Dawn* are steadily beginning to make their way over to our desktops.

So, this month we're firing back with a build that can sit under or beside your TV, using a controller or lapboard for a spot of living room gaming. If you build this PC, we want you to be able to put your feet up, pour a tall glass of your beverage of choice, and dive into your Steam library from the comfort of your couch.

Now, we're not going to beat around the bush here: As a consumer building a fresh PC, there's no way to achieve the same price-to-performance ratio as the new consoles. The digital-only Xbox Series S in particular is impossible to match without the same sort of bulk-purchase custom chip deals that Microsoft is able to make. But we're trying to keep the pricing sensible, and the higher price comes with the ability to upgrade easily down the line.

What we want here is a competent 1080p to 1440p gaming machine, using a compact chassis along with low power consumption and heat generation. Running quiet would be a bonus, but considering how noisy some consoles can get, it's not a primary concern. It should, however, be easy to clean and maintain, so an accessible case is a must-have.

You might be thinking of building this machine not for yourself, but as a stepping stone into the world of PC gaming for someone else in your life. Whether it's a child who has yet to get to grips with a mouse and keyboard, or a partner who prefers couch co-op, this system could offer a gentle introduction to gaming on PC, and should also demonstrate the benefits of a custom-build system.

That means controller compatibility (which we'll get into properly later) and RGB lighting, because we're looking at those shiny new consoles and thinking that we ought to show off a bit too. A simple but attractive aesthetic is what we're aiming for here, with customizable lighting that can be tailored to the user's preferences. Want to know what parts we've picked? Read on...

INGREDIENTS

PART		PRICE
Case	**Raijintek Ophion Evo**	$140
Mobo	**MSI MPG B550I Gaming Edge WiFi**	$200
CPU	**AMD Ryzen 3 3100**	$99
Cooler	**Stock** (AMD Wraith Stealth)	$0
GPU	**Sapphire Pulse RX 5500 XT 8 GB**	$210
Memory	**Corsair Dominator Platinum RGB 16 GB** (2 x 8 GB) **DDR4-3600**	$149
PSU	**650W Corsair RM650x**	$115
Boot Drive	**1TB Samsung 970 Evo**	$166
Fans	2x **Fractal Design Prisma RGB 120mm**	$50
OS	**Windows 10 Home OEM**	$20
Total		**$1,149**

PRICES CORRECT AT TIME OF PRINTING.

MOTHERBOARD

MSI MPG B550I Gaming Edge WiFi /$200

The new B550 format is, in a word, great. Performance and feature support on ITX boards has never been better, with MSI's WiFi 6-equipped model coming with a fan-powered M.2 heat sink and PCIe 4.0 support. While we're not using a 4th-gen M.2 SSD in this build to keep costs down, the upgrade potential is always there, and this mobo should provide an excellent base from which to build and improve a system. The product quality is also excellent, with solid thermal solutions and a clean, dark aesthetic. The BIOS is pleasingly simple to navigate, too.

CASE

Raijintek Ophion Evo /$140

An ITX case that makes excellent use of the available space and still manages to look good? Yes, it's safe to say that we like the Ophion Evo, with its dual glass panels and white aluminum chassis. This case brings a lot to the party, from USB-C support to a flexible PCIe riser that enables the GPU to be mounted upright behind the motherboard to save space. It also has room for a proper ATX power supply, rather than forcing the use of a more expensive SFX model. Will there be enough room for easy cable management? We're going to find out.

CPU COOLER

AMD Wraith Stealth / $0

It's hard not to like AMD's Wraith series of coolers. Packaged free with the Ryzen 3 3100 (as they are with most Ryzen chips), the Wraith Stealth is a relatively low-profile and quiet cooler that gets the job done without costing a cent more. The 3100 runs cool, so it doesn't really need a powerful cooler: An AIO unit would probably be overkill here. The Stealth is effective and super-easy to install, making it the obvious choice. If you're planning on overclocking the CPU, you may want a more robust cooler, but this system shouldn't hit high temperatures anyway.

AMD Ryzen 3 3100
AMD
RYZEN
100-000000284
BI 2006PGT
SM0082711A
DIFFUSED IN USA
DIFFUSED IN TAIWAN
MADE IN CHINA
© 2019 AMD
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CPU

AMD Ryzen 3 3100 / $99

If you're gaming on a budget, the Ryzen 3 3100 is a stellar choice right now. 8 threads and a 3.9MHz boost clock for under 100 bucks makes for a sweet package, and it comes with the respectable AMD Wraith Stealth cooler too. Yes, the slightly more expensive 3300X brings better performance per dollar, but it also runs hotter and uses more power. The 3100 is a lightweight chip that shouldn't struggle with low to mid-range gaming and will help keep system temperatures low. We're not using a 4th-generation M.2 drive in this build, but this chip does have PCIe 4.0 support for any future upgrades.

GPU

Sapphire Pulse RX 5500 XT 8GB / $210

This is a sensibly priced GPU that should be able to handle any game at 1080p Ultra settings and some titles at 1440p. As we said, squeezing the same amount of graphical power from a custom PC build is always going to cost more than buying a console, so we've stuck with a relatively conservative choice here. Going with this card gives us access to several handy features like Radeon Anti-Lag and AMD Link—more on that later. The 5500 XT comes in 4GB and 8GB variants; make sure you're getting the 8GB model, as the 4GB version will seriously struggle at 1440p.

SAPPHIRE PULSE
SAPPHIRE PULSE

CONTROLLER

Xbox 360 Wireless Controller. PlayStation DualShock 4. $25/$65

Really, you can use whatever control scheme you want with a system like this. We're going to be using a standard DualShock 4 gamepad from Sony, but only because we already have a PS4 knocking about. There are lots of potential options here, most of which are likely to be cheaper. If you don't mind a wired controller, older models like the Xbox 360 gamepad are an option. Alternatively, the Xbox Elite controller will cost you significantly more but is arguably the best choice for couch gaming on PC. Peripheral brands such as Logitech and Razer have their own 3rd-party offerings, too.

PSU

650W Corsair RM650x 80+ Gold /$115

A modular power supply is typically a necessity for building in an ITX case, and the Ophion Evo is no exception. There's little room for cable management here, and the lack of any SATA drives or other accessories means that we're only going to need three power cables: Motherboard ATX, CPU, and PCIe for the GPU. The RM650x's modular design ensures that we can keep this case as tidy as possible, and while it's not the cheapest PSU around, Corsair is a reliable brand, and the 80+ Gold rating will help our system's energy efficiency.

CORSAIR
RM650x
PERIPHERAL & SATA
24PIN ATX
PERIPHERAL & SATA
6+2 PCI-E & 4+4 CPU

RAM

Corsair Dominator Platinum RGB 16GB (2 x 8GB) DDR4-3600 /$149

3,600MT/s might be overkill, but the higher speed is destined to benefit the lower-end Ryzen 3 3100 processor. 16GB is generally plenty of RAM for modern gaming, and there's potential here to level it up to a 2 x 16GB kit in the future (although it's worth bearing in mind that the MPG B550I Gaming Edge WiFi only has two DIMM slots). Even if it wasn't seriously good memory, the Dominator Platinum RGB also boasts gorgeous lighting, thanks to 12 individually addressable RGB LEDs per module, fully customizable via Corsair's iCue software.

SSD

1TB Samsung 970 Evo /$166

Another "Evo" component! No relation, we're told. Samsung's 3rd-gen M.2 SSDs are a lot cheaper than they used to be, making the 970 Evo a solid choice for this build. The M.2 format saves us space inside the case (although the Ophion Evo does have room for up to four 2.5-inch SATA drives) and also means we'll need fewer cables, which is ideal in an ITX build. Samsung's drives are reliable and fast, and 1TB should be enough storage to get started with—particularly if this is a build for a PC gaming rookie.

FANS

2x Fractal Design Prisma RGB 120mm /$50

Like many ITX cases, the Ophion Evo doesn't come with any included case fans. It does have a lovely hexagonal grid with a magnetic dust filter running across the roof of the case, though. We're going to be installing two of Fractal Design's 120mm Prisma fans. RGB lighting can be handled by a single header on the motherboard, since the RGB cables on these fans can be easily daisy-chained together. The Prismas are easy to install and throw out plenty of bright rainbow lighting, while the 19.5 decibel sound rating means that this machine should never get too loud.

LITTLE BOXES

THIS SHOULD BE A STRAIGHTFORWARD JOB: CLEAR YOURSELF SOME BUILDING SPACE AND HAVE YOUR TOOLS AT THE READY

LENGTH OF TIME: **1–2 HOURS** LEVEL OF DIFFICULTY: **EASY**

1 STRIP TEASE

AS USUAL, start the build process with a stripdown of the case. The Raijintek Ophion Evo makes this nice and simple; the only things that really need removing at this stage are the two glass side panels, each of which is secured by four thumbscrews with rubber washers. These side panels are a bit delicate and prone to scratches and fingerprints, so place them back into the case box and leave them until the build is complete.

If your Ophion Evo is new, you'll need to extract a few extra bits and pieces, like the accessories bag and plastic cover on the PCIe riser cable. Leave the blue plastic cover on the PCIe connector until you're ready to plug it in: You don't want to damage it. Remove the two magnetic dust filters on the top and bottom of the case exterior. You'll be moving the case a lot during this build, and these filters can slip around.

2 ON THE EDGE

THE MPG B550I GAMING EDGE WIFI is surprisingly heavy considering its diminutive form factor, thanks to the chunky metal heat sinks all over it. Unbox it and place it on an anti-static work surface (using the top of the box is fine). It comes with plastic brackets either side of the CPU socket, which we won't be using but you can leave in place for now. However, remove the large protective sticker on the underside.

We'll mount the CPU right away. Unbox it and set the included Wraith Stealth cooler aside for later. Be careful: This may come with a pre-applied lattice of thermal solution, so don't get that all over your fingers. With the CPU in hand, simply lift up the metal retention arm by the side of the socket and drop the chip into place, ensuring that the gold triangle on one corner of the processor lines up with the matching triangle on the socket's outer edge. Once it's in position, lower the retention arm so that it clicks back into place securely.

BUDGET CONSCIOUS

IF YOU REALLY WANT to trim the fat and build a straightforward console replacement for under $500, you'll first need to accept that performance beyond 1080p likely won't be within reach. Sticking to an ITX form factor will be tough, since ITX motherboards are usually more expensive than their mATX and ATX counterparts. We recommend sticking with AMD for your processor, allowing you to use an affordable B450 chipset motherboard.

When it comes to graphics, you have two options: Track down a cheap older GPU, or commit to gaming on integrated graphics. The former option is straightforward enough: AMD's RX 560 can still be found online for around $100, with the superior RX 570 and Nvidia's GTX 1050 costing a little more. The latter is a bit more complex, since you may want to opt for an aftermarket cooler if you're planning on putting the full load of gaming on your CPU.

Integrated graphics are a lot more viable for gaming than they were a few years ago, at least. The Ryzen 5 3400G only costs $150 and can handle gaming at 1080p on medium to low graphics. No dedicated GPU saves space and effort as well as cash, and there's still the option to add a more powerful graphics card later on. Calculate your system's power draw and you may be able to choose a lower-power, cheaper PSU as well.

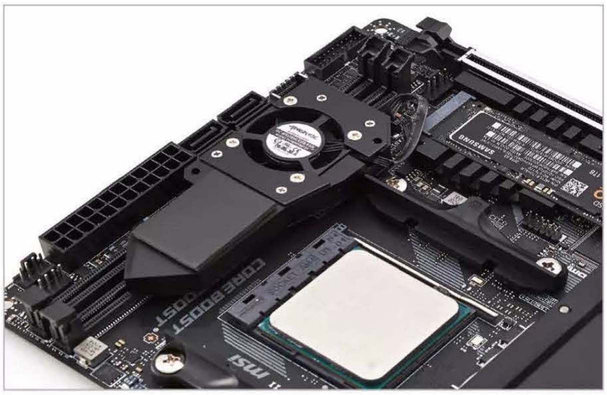
Keep an eye out for sales, and consider small adjustments that can be made for the sake of savings. Fractal Design's Prisma fans also come in cheaper, single-color variants, so you can save some cash there. Lastly, we know HDDs can be attractive for low-cost storage, but don't drop any slower than SATA SSDs if you're using it for gaming.

3

TINY FANS

YOU NEED a tiny Phillips screwdriver for this step. The M.2 drive's heat sink has a tiny fan and two screw holes, one at each end. Unscrew this carefully, ideally using a screw bowl to keep the two tiny screws safe. A good mag-tip screwdriver will come in handy here. Once the screws are removed, lift up the heat sink, but be careful: It's connected to the mobo by a very short cable, so just lay it down right beside the port.

Check that you only have one standoff in place (it may come with others pre-installed, but these can be easily removed), then plug the drive into the M.2 port. Push it down gently until the groove at the opposite end lines up with the standoff, then secure it with one of the tiny silver M.2 screws included in the motherboard box. Once it's screwed down, remove the protective film from the sticky thermal pad on the underside of the heat sink and carefully mount the sink over the drive, before screwing it back into position.

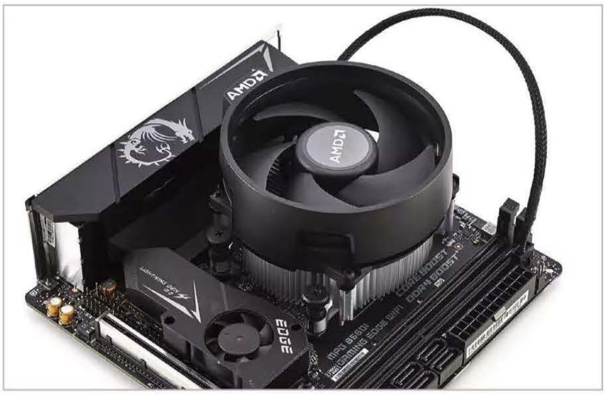


4

COOL CUSTOMER

IT'S TIME TO mount that air cooler. Remove the plastic AMD brackets either side of the CPU socket: Just unscrew them at both ends, and return the screws and the brackets to the mobo box for safekeeping. Leave the metal backplate underneath the mobo in place—you'll need it to mount the cooler.

The Wraith Stealth isn't difficult to mount, only requiring a screwdriver and a little thermal paste if it doesn't come with some pre-applied. If that is the case, just apply a pea-sized glob to the center of the CPU before proceeding. The Stealth should be positioned over the CPU so that its four screws line up with the backplate's screw holes, and the AMD logo on top points towards the rear I/O. Secure all four screws loosely first before tightening them one after the other, as the springs on each screw can require some pressure. Once the cooler is secure, run the power cable along the side of it and plug it into the "CPU_FAN" header on the motherboard.



5 MEMORY TEST

IF YOU'RE A REGULAR READER of the magazine, we can probably just say "install the memory" here and be done with it. If not, you'll need to get the two separate sticks from your Corsair kit and release the clasps at the end of the DIMM slots, before lining them up and pushing them down into place until they click at both ends. This can be a daunting task for a rookie, as the silicon undersides of RAM modules are somewhat delicate, so offer a helping hand if you're getting a PC-building newbie to assemble this machine.

Be mindful of that cooler fan cable we just plugged in, too, as the header is very close to the DIMM slots, and it may get in the way. If you need to, just unplug the cable briefly then replace it once the memory is in place. MSI has packed a lot onto this little motherboard, but that has left it looking and feeling a little cluttered.

CONTROLLING CHAOS

FINDING THE RIGHT CONTROLLER can be a complicated business, especially if you've built this PC for someone who is relatively new to gaming. A controller can be easy to get used to, so you may want to opt for something recognizable and familiar, like the classic Xbox One gamepad. This is a relatively affordable option too, costing around $50. If you want to save money, you can find a budget controller—preferably one with good reviews.

Obviously, personal preference will come into play here. The divide between aligned joysticks and offset joysticks is a deep one, with many preferring Sony's gamepad layout over Microsoft's, or vice versa. Most good 3rd-party controllers follow the Xbox design, with the twin sticks laid out asymmetrically. If you want both sticks together, we'd recommend Razer's Raiju gamepad; otherwise, Razer offers the Serval and Wildcat pads for those who prefer an Xbox layout.

You can (and should) snap up a cheap keyboard and mouse for when you're navigating the desktop, although you can use AMD Link to launch most games from your phone, bypassing the need for a mouse. If the mouse and keyboard combo is your gaming preference, though, you should investigate the possibility of purchasing either a lightweight wireless keyboard or a lapboard.

Razer, Corsair, and more offer lapboards that are designed to work with both PC and consoles, so while you should be careful to check compatibility, there are plenty of options. Razer's Turret is a whole keyboard with a built-in extending mouse mat, while most lapboards are simply a wide panel with space for a keyboard and mouse. Lastly, you could opt for the "serious" choice: A compact keypad, like the Razer Tartarus Pro, which has a grid of keys and eight-directional thumbpad for one-handed control.

6 I/O ISSUES

IF YOU TRY to mount this B550I mobo immediately, you may run into problems. The pre-installed rear I/O shield is large and inflexible, so you might find (as we have) that it won't fit properly into the cavity at the rear of the case, making screwing the mobo down to the four standoffs virtually impossible.

To rectify this, remove the rear I/O plate. This can be unscrewed from the back of the motherboard, and doesn't make much difference besides protecting the interior from dust. This case might need dusting with compressed air more often, but the motherboard will fit perfectly without the shield. The board can then be screwed down on all four corners using the screws from the Ophion Evo's accessories bag. Don't forget to feed the flexible GPU riser beneath the motherboard before screwing it down, as it will need to be plugged into the PCIe slot on the other side of the board.

8 POWER TRIP

MOUNTING THE POWER supply in the Ophion Evo is a strange process. Place the case on its side (take care not to trap any loose cables) for access to the cutout on the underside where the PSU will be fitted. Make sure the extension kettle cable isn't in the way. Unscrew the rubber foot on the corner where the PSU will be mounted. Beneath this is a small hole through which you'll need to secure one of the screws for the PSU.

Place the power brick in the case with the fan facing outwards for better airflow. Secure it with four screws, then plug the extension cable into it, and feed any slack into the case. Don't worry if the cable rises over the lip of the cutout. With the PSU mounted, replace the foot, and plug in the three power cables: Motherboard ATX, CPU, and PCIe. Feed through and plug in the first two of these now; leave the PCIe cable loose in the front of the case.

7

RAISE THE ROOF

OUR TWO PRISMA FANS are going in the roof of this build, positioned towards the rear so that they draw air more effectively from the space around the motherboard, which will be generating more heat than the PSU going at the front of the case. This can be a bit fiddly, and may require an extra pair of hands if you don't have a mag-tip screwdriver handy.

Hold the first fan (facing downwards) up against the inside of the case ceiling, all the way at the back, then secure it to the roof with four of the supplied screws. This may scratch or distort the thin aluminum of the case, which is a sign that you've over-tightened the screws. Don't worry if the screws do warp the metal slightly: It will be hidden once you replace the dust filter later. Once you're happy with the positioning of the first fan, repeat the process with the second one. Leave the cables bundled for now; we'll deal with those later on.

LINK TO PILOT

AS ANYONE WHO ALREADY OWNS an AMD GPU will probably be aware, AMD's free Radeon Software received a major boost last year, both in terms of available features and a shiny new aesthetic upgrade that unified the visual style of AMD's various software options. The current Adrenalin 2020 edition is great, enabling you to tweak overclocking settings, update drivers, and optimize your system for individual games. It also packs a host of screen-capture and recording tools, with strong support for streamers. Nvidia's GeForce Experience looks a bit feeble in comparison.

One feature that really impressed us was the new AMD Link app, available for smartphones as well as some tablets and smart TVs. This tool has been around for a few years (it first launched in 2017) and was originally designed as a simple companion app for Radeon GPUs, allowing you to perform simple actions like taking a screenshot or monitoring system temperatures. Since then, though, AMD has introduced and refined a game-streaming feature that—in our humble opinion—puts competitors to shame.

AMD Link enables you to access any game on your PC (or simply your desktop) with a few taps in the app, loading fast and playing with very little latency over a remote connection. It's usable over 4G/5G mobile networks, but we wouldn't recommend playing anything high-intensity that way. Over Wi-Fi, though, it's awesome for squeezing in a few games on your lunch break.

Of course, AMD is still refining the software and adding new features. Voice commands have recently been introduced, allowing you to bark orders at your phone and receive system information. AMD has been adamant that new features will be determined largely by user feedback, so hopefully we'll see some more worthwhile additions in the future too.

9

PROCESSING GRAPHICS

IF YOU HAVEN'T ALREADY, plug the PCIe riser into the motherboard before mounting it down. It should stretch comfortably and is flexible, although the lack of good instructions with the Ophion Evo is a frustrating. Once the riser is secure, move onto actually installing the GPU itself.

First, open the clasp on the PCIe slot mounted behind the motherboard, and remove the two blanking plates at the rear of the case. Put the plates aside or back in the case box, but keep those two screws—you'll need them to secure the GPU. Take the graphics card and line up the rear I/O with the metal slots at the rear of the case, then push it down so that it clicks into place in the PCIe slot. The clasp should snap into place once connected. Use the two screws to affix the GPU to the rear of the case, run the PCIe power cable from the PSU to the back of the case, and plug it in on top of the card.

PULSE
PULSE
M650x

10

CLEANING UP

LET'S WRAP THIS BUILD UP. Feed the front I/O and fan cables through to the mobo and plug them into the requisite headers, making sure to daisy-chain the male and female three-pin RGB cables from the Prisma fans so that you only need to use one header (that's the "J_RAINBOW" header for instant lighting effects). Unfortunately, the Ophion Evo doesn't offer a huge amount of cable management, so use cable ties to bundle the various cables as neatly as possible and secure them to whatever you can inside the case's metal frame. Ensure that no cables run over the GPU or case fans; we've put them around the short end of the card and secured them as close to the front of the case as we can.

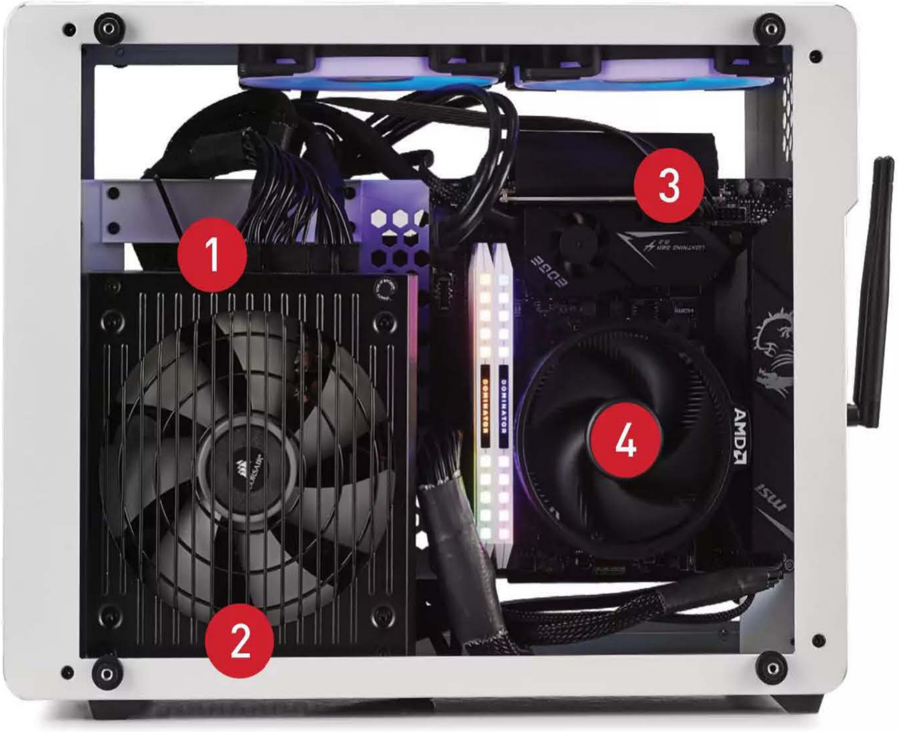
Once you're happy, replace the dust filters and side panels. Finally, take the two Wi-Fi antennas from the mobo box and screw them into place on the rear I/O. Mission accomplished!

Join the conversation!

Discuss all things PC gaming with fellow readers at our official forums

forums.pcgamer.com

PC GAMER



1 The PSU appears to take up a lot of space inside this case, but it's an intelligent solution that permits the use of a full-size ATX supply.

2 Accessing the PSU power switch can be a bit of a pain when the case is upright, but it's hardly a major problem.

3 The PCIe riser is wrapped in a durable fabric that allows it to be flexed and bent without being damaged.

4 This cooler might be basic, but given the Ryzen 3 3100's low running temperatures, it works great.

SMALL AND SOMEWHAT MIGHTY

THIS BUILD PROVED slightly more complex to assemble than we'd hoped, but that may have come down to our ham-handedness while trying to plug in tiny I/O cables inside this cramped case. The finished product looks good and runs great, though, with satisfyingly low temperatures and noise across the board. In fact, our PSU and GPU fans spend a great deal of time not spinning at all, thanks to the low power draw and heat generation.

The processor doesn't blow us away in terms of performance, and our rather basic cooling solution means that throwing any CPU-heavy loads at this system isn't going to work well, but it handles games reasonably well without getting too hot. Post-testing, we installed Ryzen Master and activated its auto-overclocking functions, which eked around five percent of additional performance from the chip without any significant increase to running temperatures. A superior aftermarket cooler might help, but at that stage you'd be better off simply upgrading to a more expensive Ryzen CPU, such as the 3300X.

The RX 5500 XT we've used here has 8GB of VRAM, a lot for a budget GPU. This will obviously benefit some games more than others, and CPU-bound titles likely won't fare as well on this machine, but shooters and platformers should perform well. Performance gains against the GTX 1060 are lower than we had hoped for, but 1080p performance was solid, and the additional features offered by the 5500 XT (such as the nifty Radeon Anti-Lag) make for a reasonable trade-off. Check out the "Link To Pilot" boxout for more on AMD's massively improved GPU software suite.

The rest of this build performs exactly as expected; the motherboard doesn't cause any bottlenecking, and the Samsung 970 Evo provides super-speedy load times in most games. While a PCIe 4.0 drive might have been superior, they're also more expensive, and the difference in transfer speeds isn't going to be noticeable to the average couch gamer. If a level loads in 1.4 seconds instead of 1.1 seconds, you shouldn't be throwing your gamepad through the television in rage.

We're not quite sure if we'd build in the Raijintek Ophion Evo again. While it achieved an impressively compact frame without sacrificing on features, building inside it proved tricky on several occasions, and cable management was a struggle. Custom-length power cables may be a necessary purchase for anyone chasing that super-clean aesthetic. We're happy with our choice of power supply, though; the RM650x gives some room for future upgrades, although we would advise against trying to install a SATA drive in this case.

Still, front-panel USB-A and USB-C is welcome, and this machine looks great perched underneath a certain staff writer's HD flatscreen. We can't match the value of next-gen consoles, but we have our own advantages: Not having to pay $70 for games is a good start. Are we being petty now? Maybe, but we'll take the Steam Summer Sale over subscription-based online play any day of the week. ⏻

BENCHMARKS

	ZERO-POINT	
Cinebench R15 Multi (Index)	1,152	1,010 (-12%)
CrystalDisk QD32 Sequential Read (MB/s)	3,400	3,575 (5%)
CrystalDisk QD32 Sequential Write (MB/s)	1,720	2,528 (47%)
Rise of the Tomb Raider (fps)	60	77 (28%)
Total War: Warhammer II (fps)	46	48 (4%)
Tom Clancy's Ghost Recon: Wildlands (Avg fps)	39	40 (3%)
3DMark: Fire Strike (Index)	11,101	11,997 (8%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our zero-point consists of an AMD Ryzen 5 1600, 16GB Crucial Ballistix Sport LT @ 2666MT/s, an EVGA GeForce GTX 1060 3GB and a 250GB Samsung 960 Evo M.2 PCIe SSD. All tests performed at 1080p at the highest graphical profile.

UBUNTU BLAST OFF!

Ubuntu is back and it's better than ever. Read on to find out why ***Jonni Bidwell*** is out of this world over this new release…

© MAGICTORCH

CANONICAL'S LATEST Ubuntu release, "Focal Fossa," hit the mirrors at the end of April. So by now thousands of people have downloaded it, installed it and (we'll bet) been downright impressed with what it has to offer. If you haven't yet tried it, then you're in for a treat.

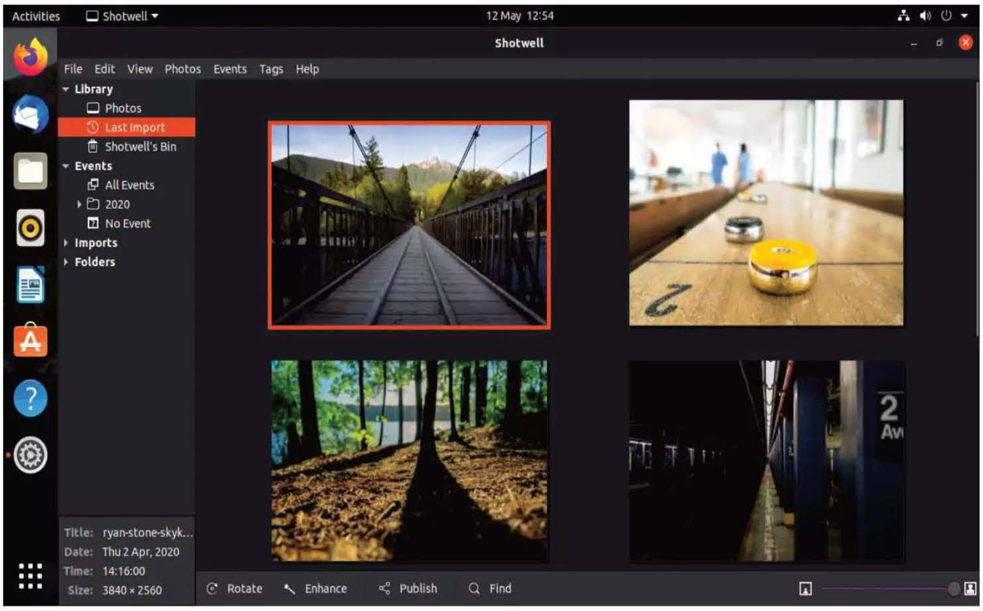
Here we'll show you what's new and what you can do with Canonical's finest. And if you've never tried Linux before, Ubuntu 20.04 LTS is a great place to start. You can try it right now (well, in the time it takes you to download and write it to a USB stick) without interfering with your current setup. We've got guides to trying out Ubuntu in a virtual machine and, when you feel ready, installing it onto bare metal.

There are all kinds of reasons to switch to Linux, and with the new Ubuntu release comes one more. Be the envy of your proprietary OS-using friends. Never see your computer crippled by updates again. Enjoy a desktop that's not an advertising space. Explore the phenomenal selection of free software, which more often than not is at least as good as commercial offerings, and in many cases is demonstrably superior. Video editing, 3D modelling, high-powered number crunching and even AAA gaming are all just a few simple clicks away.

If your desktop habits are more sedentary, Ubuntu's got you covered too. Fast web browsing, easy email, and fuss-free media playing are all yours out of the box. Read on to see just how powerful this operating system really is.

Focal Fossa Bossa Nova

It's hard to know what to focus on with this new release, so here's a quick summary of Focal Fossa's highlights



Title: ryan-stone-skyk...
Date: Thu 2 Apr, 2020
Time: 14:16:00
Size: 3840 × 2560

Ubuntu's delightful wallpapers all have a "focal" theme goin' on.

NATURALLY, everything under the Ubuntu hood has been refreshed. The 5.4 kernel brings support for new hardware and fixes for old. What most home users will be interested in is the desktop, and you'll find that Gnome 3.36 looks and behaves better than ever. It seems like there's been a two-year game of bug whack-a-mole, both within Gnome and Ubuntu's take on it, to address annoying performance and memory issues. But with this release, it's as smooth as the inferior type of peanut butter.

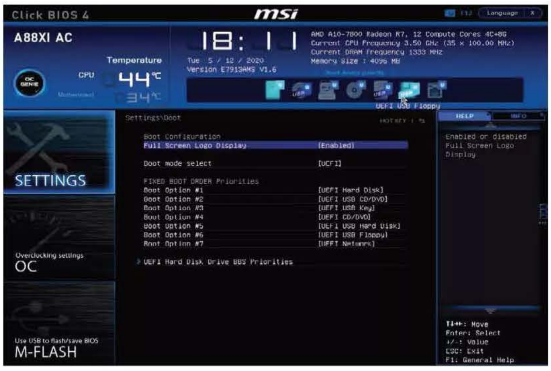
"The darkening" has come finally to Ubuntu. Like so many desktops and programs it now offers a dark mode, which some people find easier on the eyes. Light or dark, we think you'll love the new bold icons and Yaru theme. Gnome's application folders feature—in which you can drag icons in the Applications menu on top of one another to make a folder—is less clumsy now. And if you remove all but one item from a folder, then the singleton is automatically promoted back to the main menu and the folder removed. Tidy.

If you have a HiDPI display you'll be pleased to hear that fractional scaling is finally here. And (unlike in 19.10) you don't need to invoke Gsettings from the command line to use it. Previously, only integer scaling was available, which meant users often had to choose between tiny text and giant text. Now the Goldilocks Zone can be enabled through a simple switch in "Settings→Screen Display," but do note the small print warning about increased power usage and decreased sharpness. At the time of writing, there seems to be issues using this with the proprietary Nvidia driver, so keep an eye on this bug: http://bit.ly/MPCubuntubug.

Speaking of Nvidia, its drivers are included on the install medium. No need to resort to a PPA or (shudder) download them from Nvidia's website. Gamers will be pleased to hear that Feral's GameMode is part of a standard install. This can rejig CPU frequency governors, schedulers, and other frobs to boost frame rates. And in case you're concerned about the 32-bit library hassle, don't be: Everything needed by Steam, Wine, and Lutris is still in the repos. If you're running old 32-bit applications you might experience difficulties, so test these before getting rid of your 18.04 install. There's an opportunity to help the community here if you find one that doesn't work—do your bit and package it up as a Snap. Learn more from this blog post: https://snapcraft.io/blog/how-to-preserve-old-software-with-snaps.

The Ubuntu Software tool now serves Snaps as the default. Indeed, most applications we searched for were only available in this format, but some packages can be installed from the traditional Ubuntu repos. Of course, you can still install packages from the command line with apt if you're not sold on the "app store" mentality. We predict that Snaps (and Flatpaks) are going to gain serious traction in the coming months and years.

As you will see here from the Software application, a number of tools are now packaged as Snaps. And this number will very quickly increase as developers look to side-step the old method of relying on distros to package up their offerings.



```
18:11
Tue 5 / 12 / 2020
Version E7913AMS V1.6
AMD A10-7800 Radeon R7, 12 Compute Cores 4C+8G
Current CPU Frequency 3.50 GHz (35 x 100.00 MHz)
Current DRAM Frequency 1333 MHz
Memory Size : 4096 MB
UEFI USB Floppy

Settings\Boot
  Boot Configuration
  Full Screen Logo Display                [Enabled]

  Boot mode select                        [UEFI]

  FIXED BOOT ORDER Priorities
  Boot Option #1                          [UEFI Hard Disk]
  Boot Option #2                          [UEFI USB CD/DVD]
  Boot Option #3                          [UEFI USB Key]
  Boot Option #4                          [UEFI CD/DVD]
  Boot Option #5                          [UEFI USB Hard Disk]
  Boot Option #6                          [UEFI USB Floppy]
  Boot Option #7                          [UEFI Network]

> UEFI Hard Disk Drive BBS Priorities

Enabled or disabled
Full Screen Logo
Display

↑↓→←: Move
Enter: Select
+/-: Value
ESC: Exit
F1: General Help
```

Modern UEFI interfaces should make it easy to change the boot device. This one even makes it possible for you to take screenshots, which is frankly witchcraft.

© UBUNTU, MSI

Installing Ubuntu

You've got to try it to love it, but you've got to install it to really feel its power

JUST UTTERING the phrase "Installing Linux" will send a shiver down the spines of most humans, but it's not as terrifying as it used to be. Don't get overzealous, though: It's still possible to wipe out your existing OS by pushing the wrong button, and you should spend a couple of hours trying out Ubuntu before committing to installing it.

Running the live environment or installing to a virtual machine will give you a handle on the look and feel of this pinnacle of free software. There are a couple of hoops to jump through to get there, though. You can download the Ubuntu install image from whatever operating system you're comfortable with. Fire up your browser, head to https://ubuntu.com/download/desktop and press the Download button. You can also make a donation to Canonical and choose how the company invests it, but this is optional. You should now have a 2.5GB disk image (ISO) file that you can write to a DVD using the software of your choice (for example, Toast on macOS, CDBurnerXP on Windows, Brasero on Linux). We know that many PCs and most laptops don't have optical drives nowadays, but that's okay—the image can be written to a USB stick, which will probably boot much faster and certainly will be much quieter than booting from DVD. There are programs like Unetbootin that can automatically download distros and set them up in all kinds of fancy ways, but here we're recommending the cross-platform Etcher tool. Grab it from https://etcher.io, start it up, plug in a USB drive (make sure there's nothing precious on it because its contents will all be destroyed), and away you go.

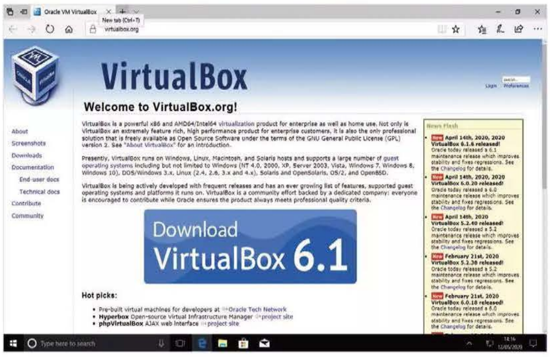
BOOT FROM YOUR ISO FILE

You'll need to figure out how to make your PC boot from USB or optical media before you can enjoy Ubuntu. You have two options. One is to open any provided Boot Menu, but not all devices offer this. The key used varies. HP systems use F9, Dell and Lenovo use F12, AMIBIOS-based systems use F8, Award-based systems use F11. You need to slowly tap the key just after switching on the system. Select any CD-ROM/Optical drive option and you're good to go.

If no boot menu is available the other option is to select the order of boot devices within the BIOS/UEFI settings. A message should appear during the system start saying which key to press. Just as with the boot menu, pressing either Del, F1, F2, Esc or a "special" maintenance key should give access. In the BIOS locate the Boot Device menu and ensure the DVD/optical drive is first in the list. Save and reboot!

You can explore the live environment risk free, but for maximum pleasure and performance install Ubuntu to your hard drive or SSD using the handy six-step guide over the page. If you have one we'd recommend installing Ubuntu to its own device, rather than resizing the Windows partition per steps one and two. It should all work fine, and in fact it's possible to carry out those steps from the Ubuntu installer. But things don't always go as they should, so back up any important data before proceeding. If you have a spare device, just select it and use the Erase disk and install Ubuntu option in step four. If you want to play it safe, another option is to install Ubuntu to a virtual machine using Oracle's VirtualBox.

INSTALLING IN VIRTUALBOX



VirtualBox

Welcome to VirtualBox.org!

VirtualBox is a powerful x86 and AMD64/Intel64 virtualization product for enterprise as well as home use. Not only is VirtualBox an extremely feature rich, high performance product for enterprise customers, it is also the only professional solution that is freely available as Open Source Software under the terms of the GNU General Public License (GPL) version 2. See "About VirtualBox" for an introduction.

Presently, VirtualBox runs on Windows, Linux, Macintosh, and Solaris hosts and supports a large number of guest operating systems including but not limited to Windows (NT 4.0, 2000, XP, Server 2003, Vista, Windows 7, Windows 8, Windows 10), DOS/Windows 3.x, Linux (2.4, 2.6, 3.x and 4.x), Solaris and OpenSolaris, OS/2, and OpenBSD.

VirtualBox is being actively developed with frequent releases and has an ever growing list of features, supported guest operating systems and platforms it runs on. VirtualBox is a community effort backed by a dedicated company: everyone is encouraged to contribute while Oracle ensures the product always meets professional quality criteria.

Download VirtualBox 6.1

Hot picks:

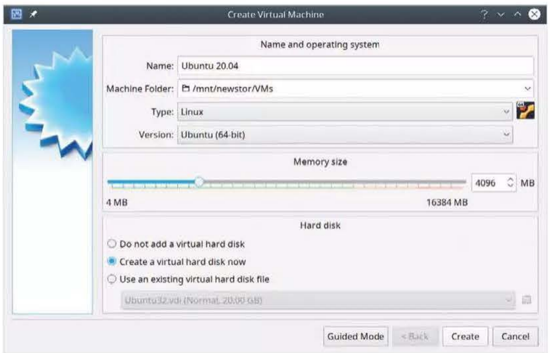
- Pre-built virtual machines for developers at Oracle Tech Network
- Hyperbox Open-source Virtual Infrastructure Manager project site
- phpVirtualBox AJAX web interface project site

News Flash

- New April 14th, 2020, 2020 VirtualBox 6.1.6 released! Oracle today released a 6.1 maintenance release which improves stability and fixes regressions. See the Changelog for details.
- New April 14th, 2020, 2020 VirtualBox 6.0.20 released! Oracle today released a 6.0 maintenance release which improves stability and fixes regressions. See the Changelog for details.
- New April 14th, 2020 VirtualBox 5.2.40 released! Oracle today released a 5.2 maintenance release which improves stability and fixes regressions. See the Changelog for details.
- New February 21st, 2020 VirtualBox 5.2.38 released! Oracle today released a 5.2 maintenance release which improves stability and fixes regressions. See the Changelog for details.
- New February 21st, 2020 VirtualBox 6.0.18 released! Oracle today released a 6.0 maintenance release which improves stability and fixes regressions. See the Changelog for details.

1 GET VIRTUALBOX

Head to www.virtualbox.org and download VirtualBox 6 for your operating system, be that Windows or OS X. Install it and be aware you'll need at least 20GB of drive space to store the virtual OS file. You'll also need the Ubuntu ISO file from www.ubuntu.com/desktop/download. Once installed, start it and click the "New" button and call it "Ubuntu."



Create Virtual Machine

Name and operating system

Name: Ubuntu 20.04

Machine Folder: /mnt/newstor/VMs

Type: Linux

Version: Ubuntu (64-bit)

Memory size: 4096 MB

Hard disk

○ Do not add a virtual hard disk

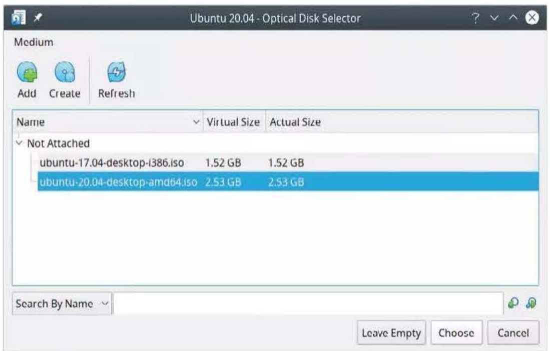
● Create a virtual hard disk now

○ Use an existing virtual hard disk file

Ubuntu32.vdi (Normal, 20.00 GB)

2 CREATE A MACHINE

Choose Ubuntu, and the bits should match the ISO you downloaded, then click "Next." Under Memory we'd recommend 2,048, but if you have an 8GB PC, 4,096 is best. You can leave all the rest as default settings, apart from the dynamic hard drive size. The default is 8GB, but we suggest at least 32GB if you can spare. Finish and click "Start" to get going.



Ubuntu 20.04 - Optical Disk Selector

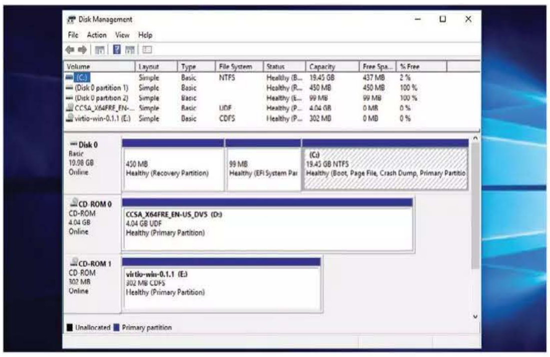
Name	Virtual Size	Actual Size
Not Attached		
ubuntu-17.04-desktop-i386.iso	1.52 GB	1.52 GB
ubuntu-20.04-desktop-amd64.iso	2.53 GB	2.53 GB

3 STARTING VIRTUAL UBUNTU

A prompt will appear asking for a disc—locate the Ubuntu ISO file and click "Start." Linux Ubuntu will start, and once loaded you're free to try out Ubuntu or use the "Install" icon to properly install it to the virtual machine. For extended use, in the virtual machine's settings under "Display," you'll want to enable 3D acceleration and allocate 16MB.

© VIRTUALBOX

INSTALL UBUNTU WITH WINDOWS



Volume	Layout	Type	File System	Status	Capacity	Free Spa...	% Free
(C:)	Simple	Basic	NTFS	Healthy (B...	19.45 GB	437 MB	2 %
(Disk 0 partition 1)	Simple	Basic		Healthy (R...	450 MB	450 MB	100 %
(Disk 0 partition 2)	Simple	Basic		Healthy (E...	99 MB	99 MB	100 %
CCSA_X64FRE_EN-...	Simple	Basic	UDF	Healthy (P...	4.04 GB	0 MB	0 %
virtio-win-0.1.1 (E:)	Simple	Basic	CDFS	Healthy (P...	302 MB	0 MB	0 %

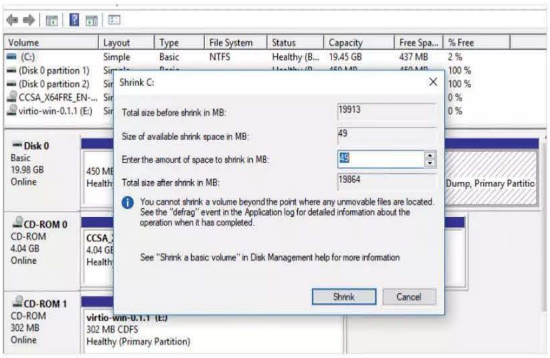
Disk 0
Basic
19.98 GB
Online
450 MB
Healthy (Recovery Partition)
99 MB
Healthy (EFI System Par
(C:)
19.45 GB NTFS
Healthy (Boot, Page File, Crash Dump, Primary Partitio

CD-ROM 0
CD-ROM
4.04 GB
Online
CCSA_X64FRE_EN-US_DV5 (D:)
4.04 GB UDF
Healthy (Primary Partition)

CD-ROM 1
CD-ROM
302 MB
Online
virtio-win-0.1.1 (E:)
302 MB CDFS
Healthy (Primary Partition)

1 MAKE ROOM

To create an empty partition for your Ubuntu installation, you'll first have to squeeze your existing Windows partition. Fire up the Disk Management tool in Windows, and right-click your main partition that's typically assigned the drive letter C. Then select the "Shrink Volume" option from the pop-up menu.



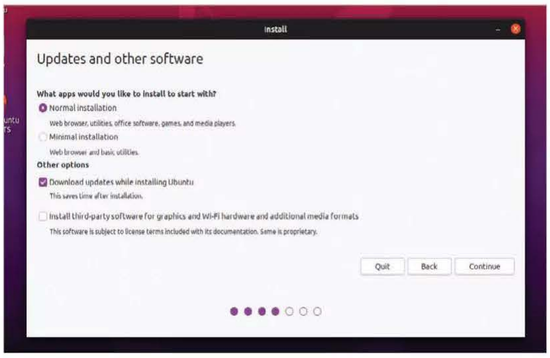
Total size before shrink in MB: 19913
Size of available shrink space in MB: 49
Enter the amount of space to shrink in MB: 49
Total size after shrink in MB: 19864

You cannot shrink a volume beyond the point where any unmovable files are located. See the "defrag" event in the Application log for detailed information about the operation when it has completed.

See "Shrink a basic volume" in Disk Management help for more information

2 SHRINK WINDOWS

This brings up the Shrink dialog that shows you the total size of the hard drive and the maximum amount of space that you can squeeze out of the selected partition. To create a new partition, specify the size of the partition in the space provided in megabytes and click "Shrink" to start the process.



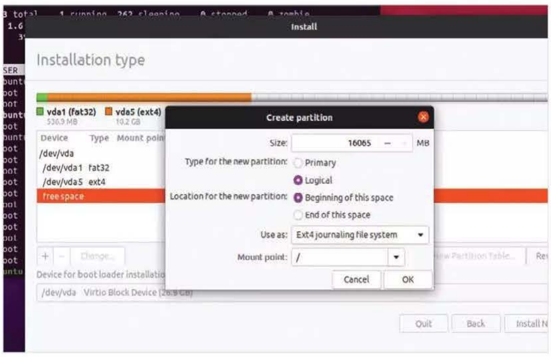
Updates and other software

What apps would you like to install to start with?
● Normal installation
Web browser, utilities, office software, games, and media players.
○ Minimal installation
Web browser and basic utilities.
Other options
☑ Download updates while installing Ubuntu
This saves time after installation.
☐ Install third-party software for graphics and Wi-Fi hardware and additional media formats
This software is subject to license terms included with its documentation. Some is proprietary.

3 UPDATES AND PLUGINS

After your computer boots from the Ubuntu installation medium, it will display a checklist. Toggle the two available checkboxes on this screen. The first checkbox option will fetch any available updates from the internet, and the other will install the plugin required to play MP3 content and Wi-Fi firmware.

© MICROSOFT



Installation type

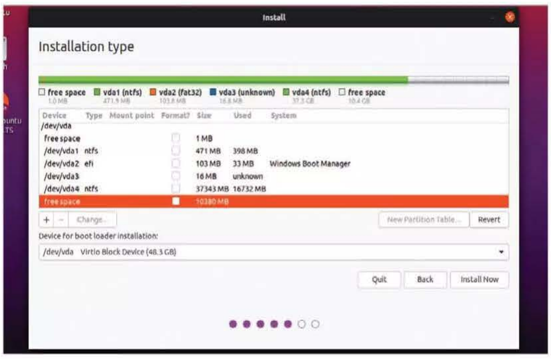
vda1 (fat32) 536.9 MB · vda5 (ext4) 10.2 GB

Device Type
/dev/vda
/dev/vda1 fat32
/dev/vda5 ext4
free space

Size: 16065 MB
Type for the new partition: ○ Primary ● Logical
Location for the new partition: ● Beginning of this space ○ End of this space
Use as: Ext4 journaling file system
Mount point: /

4 USE FREE SPACE

In the screen labeled "Installation type," toggle the "Something else" radio button to manually partition the disk. Ubuntu will now show you a list of partitions on the hard drive. Select the one labelled "Free Space" and click the plus sign (+) to create a partition out of this space you freed up in Windows.



Installation type

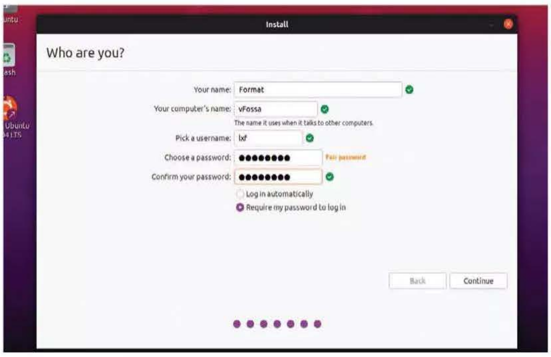
free space 1.0 MB · vda1 (ntfs) 471.9 MB · vda2 (fat32) 103.8 MB · vda3 (unknown) 16.8 MB · vda4 (ntfs) 37.3 GB · free space 10.4 GB

Device	Type	Mount point	Format?	Size	Used	System
/dev/vda						
free space			☐	1 MB		
/dev/vda1	ntfs		☐	471 MB	398 MB	
/dev/vda2	efi		☐	103 MB	33 MB	Windows Boot Manager
/dev/vda3			☐	16 MB	unknown	
/dev/vda4	ntfs		☐	37343 MB	16732 MB	
free space			☐	10380 MB		

Device for boot loader installation:
/dev/vda Virtio Block Device (48.3 GB)

5 DEFINE PARTITIONS

In the Create partition box enter the size for the Ubuntu partition. Then use the "Mount point" pull-down menu to select the / option. If you like, you can create a separate home partition (if you want to keep user files and system files separate) in exactly the same way. Just select "/home" from the menu.



Who are you?

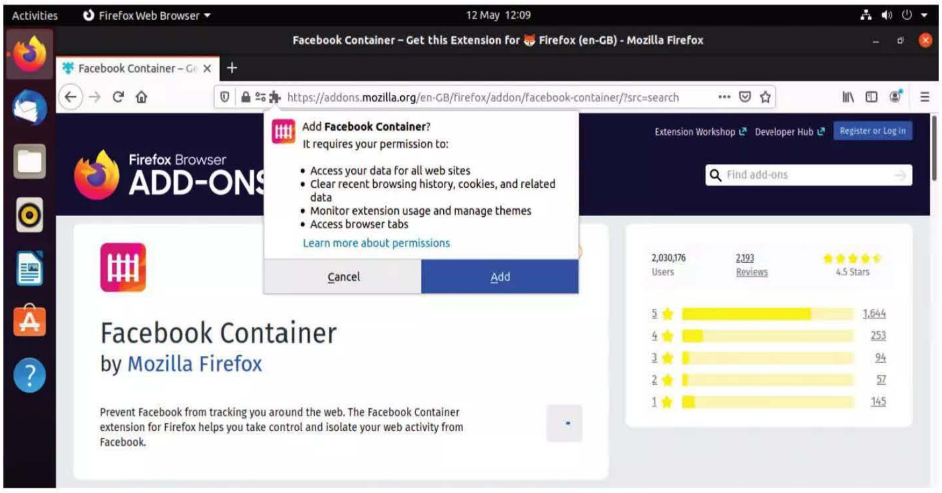
Your name: Format
Your computer's name: vFossa
The name it uses when it talks to other computers.
Pick a username: lxf
Choose a password: ●●●●●●●● Fair password
Confirm your password: ●●●●●●●●
○ Log in automatically
● Require my password to log in

6 LOCALISE AND PERSONALISE

And that's it. The installer will now start the process of installing Ubuntu. While the files are being copied to the hard drive in the background, it'll ask about your locale. In the last screen you'll be asked to enter your desired login and password details, as well as a name for your computer.

Desktop Deep Dive

Here's a quick guide to Ubuntu's top-notch take on the Gnome desktop


Activities
Firefox Web Browser
12 May 12:09
Facebook Container – Get this Extension for Firefox (en-GB) - Mozilla Firefox
Facebook Container – Ge
https://addons.mozilla.org/en-GB/firefox/addon/facebook-container/?src=search
Firefox Browser
ADD-ONS
Extension Workshop
Developer Hub
Register or Log in
Find add-ons
Cancel
Add
2,030,176
Users
2,193
Reviews
4.5 Stars
5
1,644
4
253
3
94
2
57
1
145
Facebook Container
by Mozilla Firefox

Add **Facebook Container**?
It requires your permission to:

- Access your data for all web sites
- Clear recent browsing history, cookies, and related data
- Monitor extension usage and manage themes
- Access browser tabs

Learn more about permissions

Prevent Facebook from tracking you around the web. The Facebook Container extension for Firefox helps you take control and isolate your web activity from Facebook.

If you can't banish Facebook, you can at least contain it thanks to this excellent Firefox plugin.

COMING FROM WINDOWS or macOS, Ubuntu at first glance appears dramatically different. But don't worry, soon it will feel just like home. Your first port of call might be the Applications menu, which you can access by clicking in the top left of the screen, or by pressing the Super (Windows) key. This shows any running applications, or if there aren't any it will show frequently used ones. So the first time you click it this view will be barren. You'll find a grid of installed applications by clicking in the bottom right, so have a nose around to see what interests you.

The standard install includes everything you need to get started, and tries to avoid bundling things that you don't. Perhaps we should have mentioned earlier the minimal install option if you don't need an office suite, games, or other computing fripperies. This saves you around half a gigabyte.

Sooner or later you'll want to add some applications, and the easiest way to do this is through the Ubuntu Software shortcut in the dock (the one that looks like an orange briefcase). One of our first additions is the Gnome Tweaks tool, which makes it possible for you to customize the desktop's appearance and behavior in lots of ways. Depending on who you believe, this either should not exist at all, or should be included by default on the Gnome desktop. We'll let you be the judge: Just search for "tweak in Ubuntu software," click the green install button, and confirm with your password.

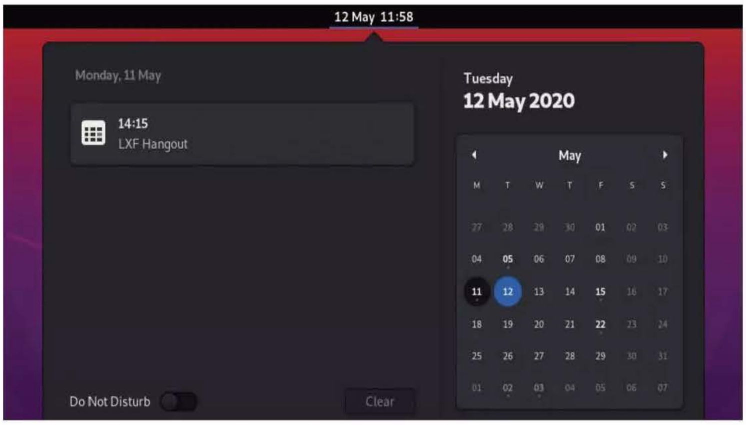
The installer will have prompted you to add any online accounts you have, such as Facebook or Google. These will integrate with your desktop calendar and file manager as appropriate, so you can browse Google Drive or receive Facebook notifications. If you didn't add these accounts earlier you can always add them by going to "Settings→Online Accounts." You'll probably find you need to log out and log back in before calendars and other things sync properly. If you have successfully connected accounts and are tired of all these notifications you can remove them from here too. Alternatively, the "Do Not Disturb" switch in the calendar panel will silence these and hopefully keep you focused.

FAVORITE FLAVOR

If you don't like Ubuntu's desktop, there are other flavours available. Kubuntu, powered by the slick KDE Plasma desktop, has a slightly more Windows-like feel. Visit **https://ubuntu.com/download/flavours** to see the whole selection. You don't need to install a whole new distro just to try a new desktop, though. For example, if you want to try pure Gnome (without Ubuntu's tweaks) then fire up the Terminal app and type the following:

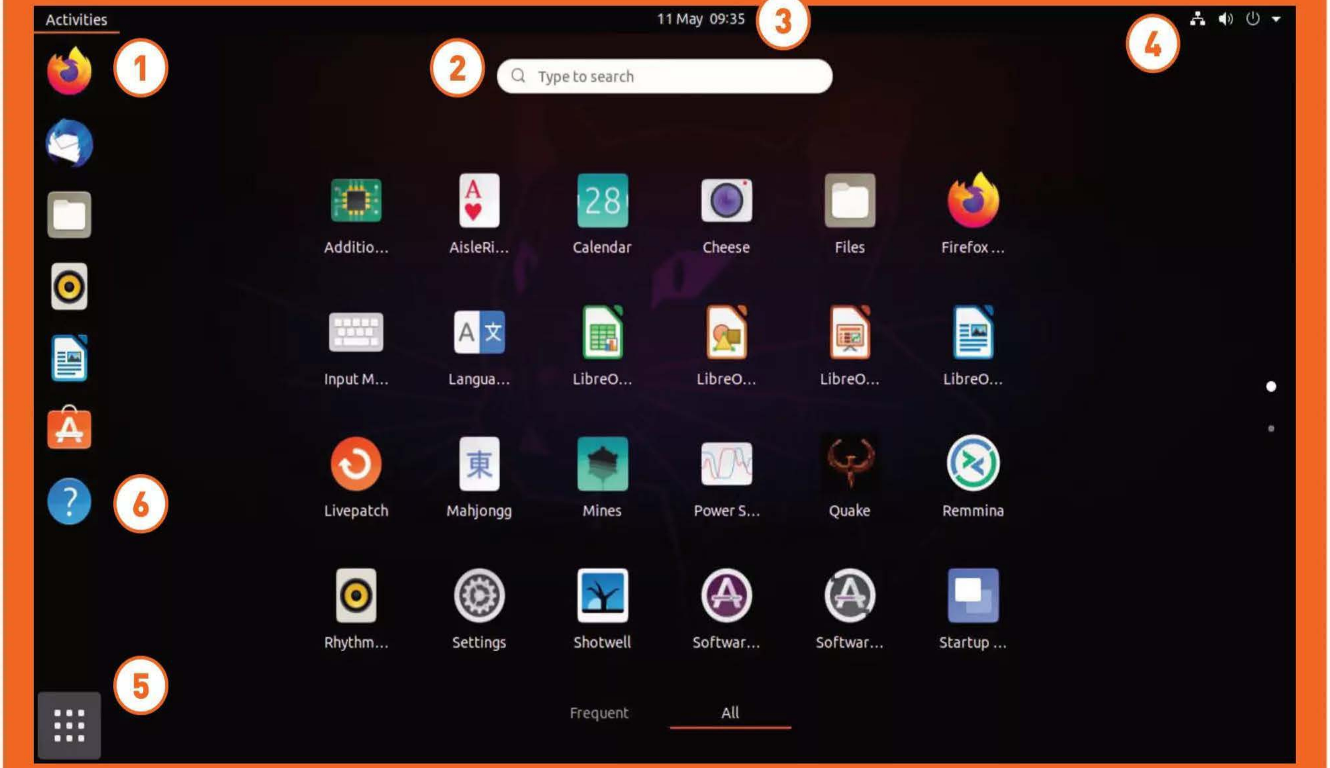
```
$ sudo apt install ubuntu-gnome-desktop
```

You can then choose the Gnome session from the login screen: Just click the cog icon in the bottom-right and choose Gnome. Unlike the Ubuntu session, this uses the newer Wayland protocol for talking to the displays. This should work well (at least with open-source drivers) by now, but if you run into difficulties try Gnome on Xorg instead. Other desktop environments can be installed this way too, via the `kubuntu-desktop`, `ubuntu-mate-desktop`, `ubuntu-budgie-desktop` and other such packages. Once you've settled on your favorite desktop, you may consider reinstalling the corresponding flavor in the name of tidiness. Each desktop will install its own core applications, so there will be some duplication.


12 May 11:58
Monday, 11 May
14:15
LXF Hangout
Tuesday
12 May 2020
May
M
T
W
T
F
S
S
Do Not Disturb
Clear

The Gnome session lacks Ubuntu's characteristic left sidebar. And the darker colors bring looming deadlines into stark relief.

GETTING TO GNOME YOU...


Activities
11 May 09:35
Type to search
1
2
3
4
5
6
Additio...
AisleRi...
Calendar
Cheese
Files
Firefox ...
Input M...
Langua...
LibreO...
LibreO...
LibreO...
LibreO...
Livepatch
Mahjongg
Mines
Power S...
Quake
Remmina
Rhythm...
Settings
Shotwell
Softwar...
Softwar...
Startup ...
Frequent
All

1. ACTIVITIES
Clicking here (or, alternatively, pressing the Superkey) launches the Activities view. Helpfully, this shows you previews of your running programs on the system.

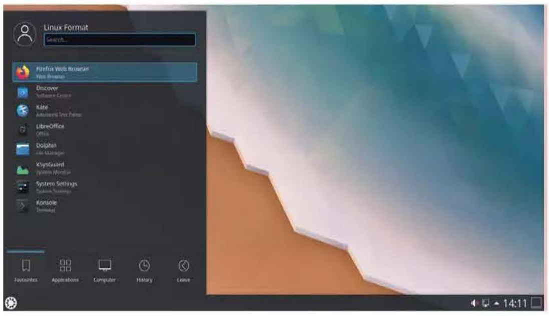
2. SEARCH BOX
Start typing in the Activities view (there is no need to click in the box) to search Apps, Docs and anything else you may need to find.

3. CALENDAR AND NOTIFICATIONS AREA
Click here to control music, see any appointments (if you've connected an appropriate service) or activate Do not Disturb mode.

4. STATUS MENU
Network settings (including VPN), volume controls, and application indicators can be found here. The button in the bottom left launches the all-important Settings tool.

5. APPLICATIONS MENU
Click here to open/close a view of frequently used applications. You can see all installed applications from the selector at the bottom of this menu.

6. DOCK
Launch your favorite applications from here. Right-clicking a running application (denoted by a dot) enables you to add it to the dock for easier and more convenient access.


Linux Format
Firefox Web Browser
Discover
Kate
LibreOffice
Dolphin
KSysGuard
System Settings
Konsole
14:11

KDE Plasma is traditional in the sense that there's a menu in the bottom left, but it's sleek and modern looking, too.

BROWSER WARS

We're particularly enamored with Firefox 76 and its stylish new interface. If you're coming from the proprietary world then Google Chrome may be your browser of choice, and if you really want that then it's straightforward enough to install (and its open-source sibling Chromium is even easier). But we think you should give Firefox a chance, if only for the privacy-preserving Facebook Container add-on. And indeed the multi-account container add-on, because tracking on the web is out of control these days.

Often it's the hate-ridden Windows updates that cause people to switch to Linux. Ubuntu is much more considered in its updates. There's an unattended upgrades service that applies urgent fixes in the background, but you'll be told (not forced) about general package updates. These can be applied at a convenient time from the Software application or the command line. Contrary to what you might read elsewhere, it's entirely possible to use desktop Linux without memorizing a bunch of strange command line incantations or having a PhD in regular expressions. It's hard to overestimate how powerful the terminal is, but for desktop use you'd be better off memorizing a couple of keyboard shortcuts for Gnome instead:

- **Super (Windows key)** Bring up the activities view
- **Super-Left/Right** Tile current application left or right (so it fully occupies one half of the screen)
- **Super-Up/Down** Maximize/restore current application
- **Super-PgUp/PgDown** Switch virtual desktops
- **Super-Shift-PgUp/Dn** Move current application to next/previous virtual desktop.

Under The Hood

There are subtle changes and understated improvements in Ubuntu 20.04 that really deserve mentioning

WE GET IT. A new Ubuntu release, even an LTS, isn't the cause célèbre it once was. But we've always said that this lack of ground-breaking change is a good thing. It shows that Ubuntu has reached such a level of maturity that refinement, and not radical rewriting of the rules, is the optimal path. We also understand that there are plenty of other distros suitable for beginners (and let's stress here that Ubuntu is popular with professionals too), and maybe some of those don't get the attention that Ubuntu does. All that aside, Ubuntu remains one of the most popular distros among Linux users in general.

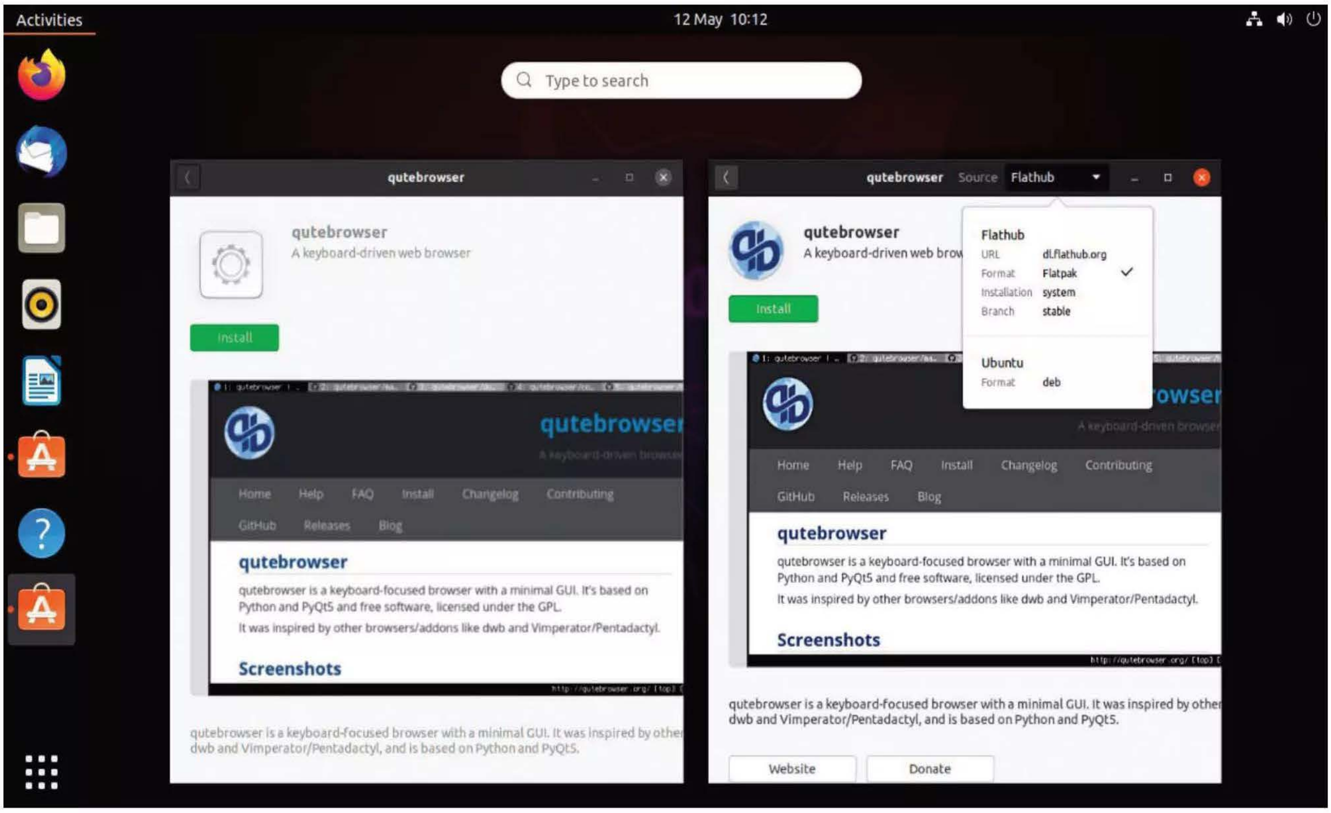
In this new outing you'll find support for AMD's Navi 12 and 14 GPUs as well as its new APUs, and the open-source Nouveau driver has improved color management. There's support for Intel's Comet Lake chips and initial support for its 11th-gen Tiger Lake architecture. The Kernel Lockdown security module also debuts in this release, which limits userspace code (even if it's running as root) from interfering with kernel operations. First proposed by security guru Matthew Garrett some years ago, this is aimed at admins who want to limit the damage a compromised root account can cause.

Two software tools, both alike in dignity in fair Ubuntu where we lay our scene.

There are a couple of noteworthy filesystem changes: Support for Microsoft's newly (sort of) open sourced exFAT, as well as the speedy VirtIO-FS for sharing directories with virtual machines. Ubuntu also backports lots of features from newer kernels, and one notable addition is support for Wireguard VPNs. In an age of surveillance and dubious sponsored "best VPN" listicles, this will surely be a boon for privacy. It's early days yet, but we forsee Wireguard being key to demystifying the VPN sphere. It's small, fast and much easier to get your head around than OpenVPN, being much more akin to setting up an SSH server.

STORAGE OPTIONS

Moving into lower userspace, there's systemd 245, which features the new home directory regime `systemd-homed`. Don't worry though, Ubuntu doesn't use this by default, and to be honest we weren't able to activate it so it looks like this feature hasn't been built into the package. Again, early days. There's also an experimental option to install using the next-generation ZFS filesystem, whose roots go back to Oracle's Solaris. Licencing conflicts have kept this out of the Linux kernel, and it's not a thing your average user will want. But if you have insane storage, lots of memory, and deduplication requirements, ZFS is a mere checkbox in the installer away. Ubuntu's zsys middleware will automatically snapshot filesystems



qutebrowser
A keyboard-driven web browser

qutebrowser is a keyboard-focused browser with a minimal GUI. It's based on Python and PyQt5 and free software, licensed under the GPL.

It was inspired by other browsers/addons like dwb and Vimperator/Pentadactyl.

qutebrowser is a keyboard-focused browser with a minimal GUI. It was inspired by othe dwb and Vimperator/Pentadactyl, and is based on Python and PyQt5.

Flathub
URL dl.flathub.org
Format Flatpak ✓
Installation system
Branch stable

Ubuntu
Format deb

qutebrowser is a keyboard-focused browser with a minimal GUI. It's based on Python and PyQt5 and free software, licensed under the GPL.

It was inspired by other browsers/addons like dwb and Vimperator/Pentadactyl.

qutebrowser is a keyboard-focused browser with a minimal GUI. It was inspired by other dwb and Vimperator/Pentadactyl, and is based on Python and PyQt5.

before software updates, so they can be undone if things go south.

There's a new, officially supported target to get excited about, the Raspberry Pi (models 2, 3, and 4). Not only is this great for home users, particularly those who want to take advantage of the Pi 3 and 4's Aarch64/ARMv8 OS hardware, but having Canonical's certification will encourage enterprises to do great things with the Pi. Read more about this on Rhys Davies's post on the official Ubuntu blog at https://ubuntu.com/blog/ubuntu-20-04-lts-is-certified-for-the-raspberry-pi.

The certification only applies to Ubuntu Server, and that's the only Raspberry Pi download that's offered through Canonical's website, but it's straightforward to add a desktop, for example, via the xubuntu-desktop package. If you have a Pi 4 and want to take advantage of its extra oomph, why not install KDE Plasma? At the moment the official Gnome desktop isn't supported on the Pi, but don't forget an Ubuntu MATE SD card image is available (from https://ubuntu-mate.org) if you want a ready-to-roll desktop. The MATE desktop is ideal for lower-powered devices, or just people who liked Gnome 2. MATE images are also available for UMPCs such as the GPD Pocket and MicroPC.

Flatpaks can't be installed from the Ubuntu Software app, but are available from the command line. If you want to install them GUI style you can install the vanilla Gnome Software application, add the Flatpak plugin, and then add the Flathub repo with:

```
$ sudo apt install gnome-software
gnome-software-plugin-flatpak
```

```
$ flatpak remote-add --if-not-exists
flathub https://flathub.org/repo/
flathub.flatpakrepo
```

Note the message about the search path: A restart is required before Flatpak apps show up in the applications menu. Slightly confusingly, you'll now find two app stores, Ubuntu Software and Software, in the applications menu. The latter will enable you to install from the whole gamut of package sources: Flatpaks, Snaps or good old-fashioned DEBs. So you could even uninstall the `snap-store` package if you want. The screenshot (left) shows the differences between the Snap and Flatpak versions of Qutebrowser.

Get your hardware secured, Elliptic Curve DSA SSH key game on with OpenSSH 8.2.

fido
ALLIANCE

As for security features there are a few things you can do with hardware tokens such as the Nitrokey and Yubikey. If you have a FIDO (Fast IDentity Online) or U2F (Universal second Factor) device, then not only can you use it to log in locally (using the pam_u2f module), you can also use it remotely. New key types introduced in OpenSSH 8.2 can work with these devices, enhancing security when logging in to your Ubuntu device via SSH. You might already be familiar with the idea of using an SSH key instead of (or as well as) a password. Basically, generate a key on the local system with `ssh-keygen` then copy it to the remote one with `ssh-copy-id`. Well now, if you attach your hardware token and run

```
$ ssh-keygen -t ecdsa-sk
```

you'll be prompted to tap the authenticator as well as provide an optional password. You can then copy this key to remote systems as before. In order to log in with the new key, for now, you'll need to specify it with the following:

```
$ ssh -i ~/.ssh/id_ecdsa_sk
myserver.com
```

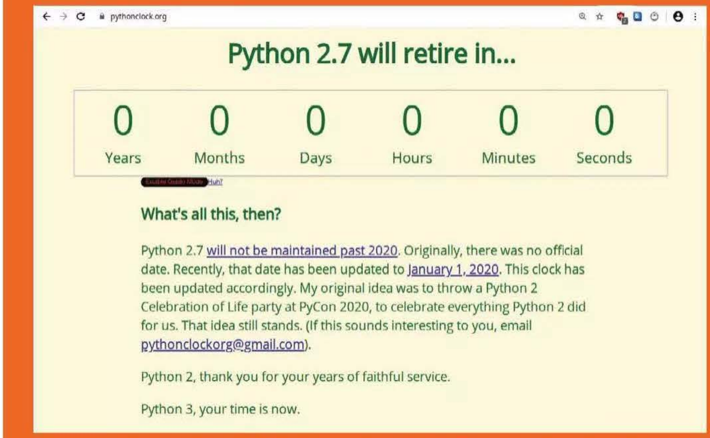
THAT'S ALL FOLKS

We haven't covered running Ubuntu on Windows via WSL, but with WSL 2 going mainstream soon, that certainly will be an interesting endeavor, though perhaps one that interests developers more than home users. If you're running Ubuntu 18.04 on your server, it's probably wise to go for the 20.04.1 point release. There's much more to Ubuntu and we'd love to hear your opinions on it and its many other flavors. ⏻

OUT WITH THE OLD...

32-bit PC users won't be able to enjoy this new release. There's no upgrade path from 32-bit 18.04, as there was from 16.04—the last LTS to offer a 32-bit install medium. And that's a bit of a shame because it's great. But those users can continue to use 18.04 for another three years, so no need to panic yet. Also gone from the default install is Python 2, and the vast majority of packages in the repositories have been upgraded to use Python 3. The older version reached end-of-life at the start of this year, but the package is still available for the few projects that still rely on it.

Finally, a small thing, but one that makes us incredibly happy. That horrible Amazon link in the launcher has gone. It has irked us since it debuted in 2012. The only thing it was useful for was teaching users how to remove icons from the dock. Veterans will recall that previous Ubuntu releases included Amazon links when searching in the Unity HUD, but those days are long gone. Speaking of Unity, if you really miss that desktop, you can install it from the `ubuntu-unity-desktop` package. Alternatively, you can go all out and try the Unity remix. Find out more about this at https://discourse.ubuntu.com/t/ubuntu-unity-remix-20-04.



Python 2.7 will retire in...

What's all this, then?

Python 2.7 will not be maintained past 2020. Originally, there was no official date. Recently, that date has been updated to January 1, 2020. This clock has been updated accordingly. My original idea was to throw a Python 2 Celebration of Life party at PyCon 2020, to celebrate everything Python 2 did for us. That idea still stands. (If this sounds interesting to you, email pythonclockorg@gmail.com).

Python 2, thank you for your years of faithful service.

Python 3, your time is now.

Remember back in LXF195 when we told you Python 2 is going away? It's still going away.

RTX

NVIDIA AMPERE ARCHITECTURE DEEP DIVE

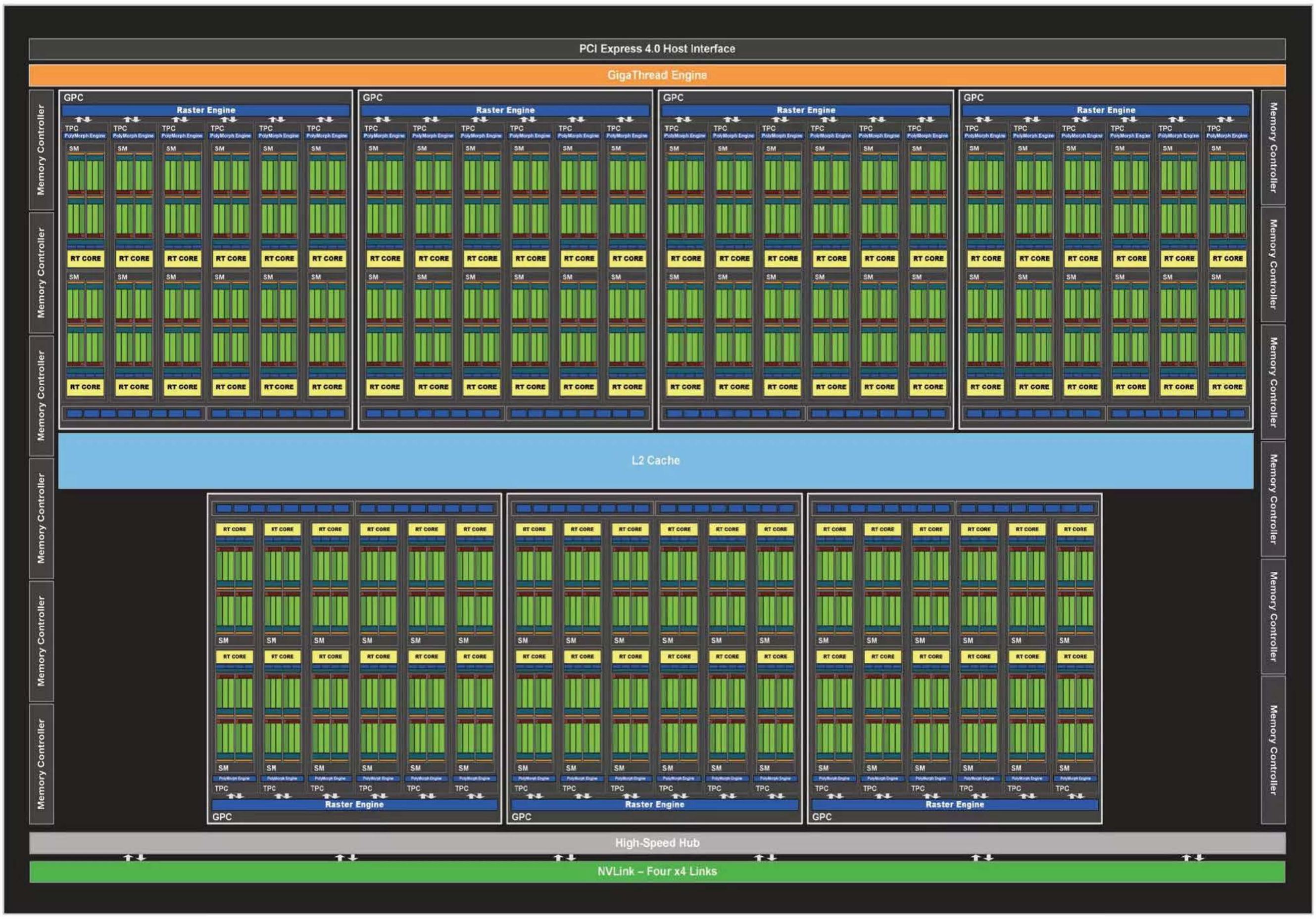
Put on your swimsuit, because we're about to get wet

IT'S BEEN TWO YEARS since Nvidia unveiled the Turing architecture, ushering in the new era of ray-traced graphics for games. OK, let's be frank: Ray-tracing adoption in games has been sluggish and often underwhelming. More accurate reflections, slightly improved shadows? Yawn. We want it all: Reflections, refractions, shadows, global illumination, caustics, ambient occlusion! The problem is that each of those effects increases the burden placed on the ray-tracing hardware and your GPU, so developers often picked one or a few effects at most. But that all changes with Nvidia's Ampere architecture.

Take everything that was great about Turing and basically double down, and you get an idea of what Nvidia has planned for Ampere. We have a full review of the GeForce RTX 3080 Founders Edition [See page 68], the fastest graphics card ever to grace the inside of your PC. Well, sort of—we'll be looking at the GeForce RTX 3090 Founders Edition next month. But for most gamers, even those with deep pockets, the RTX 3080 makes more sense. It's perhaps the largest generational improvement in performance ever from Nvidia, and it makes yesterday's RTX 2080 Ti look like an overpriced has-been. And it all comes down to the new, superior Ampere architecture.

Let's start from the top, and cover all the major changes. We can't possibly cover every item that's changed, though if you're really interested in learning more, Google "Nvidia Ampere Whitepaper" and you can get the raw, undistilled version. We're also going to confine our discussion to just the GA102/GA104 "gaming" GPUs—there's also a new GA100 chip used for supercomputers and deep learning that's quite different from the consumer version of Ampere.

JARRED WALTON



This "simplified" block diagram illustrates just how complex modern GPUs have become.

Lithography:

The Foundation of Every Chip

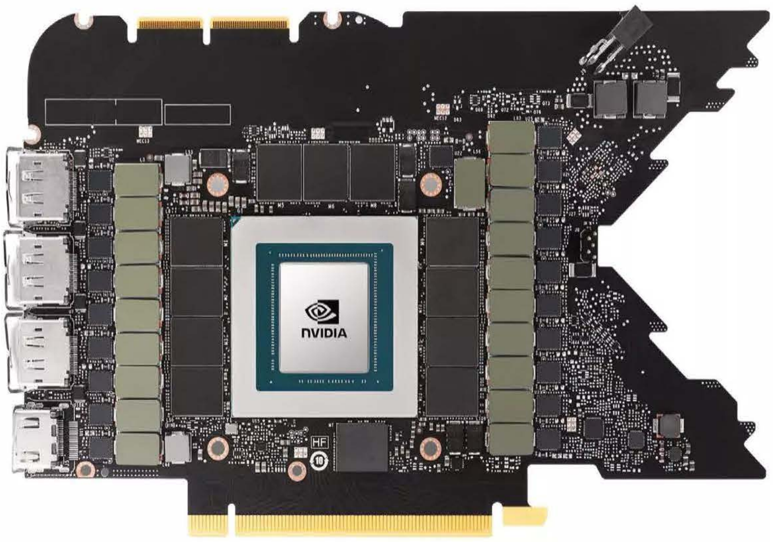
Every chip design starts by choosing how the part will eventually be made. Most of Nvidia's GPUs of the past two decades have come from TSMC (Taiwanese Semiconductor Manufacturing Company), but Nvidia has also used Samsung for some parts. The GA102 and GA104 chips destined for the RTX 30-series cards will use Samsung 8N, an "Nvidia-optimized" 8nm process technology that's basically Samsung's 10LP++++. That's almost as many "+" revisions as intel's 14nm node! This brings along some good improvements compared to Turing (TSMC 12FFN), allowing for more transistors in a smaller space.

However, let's be clear: TSMC's N7 lithography is undoubtedly better overall, if you're just looking at performance. It's also in much higher demand, which is almost certainly why Nvidia opted for Samsung. TSMC is currently busy taking orders from AMD for Zen 2, the upcoming Zen 3, RDNA 1, the upcoming RDNA 2, and Nvidia's own GA100 chips—plus Apple and various other customers. Word is that TSMC is basically in such high demand that it can charge a premium, and it does.

Just from a high level, however, Samsung 8N is still a healthy jump for Nvidia. Consider the previous-generation TU102 GPU used in the RTX 2080 Ti. It has 18.6 billion transistors crammed into a massive 754mm square chip. The Ampere GA102 by comparison has 28.3 billion transistors in a 628mm square chip. It's not entirely apples to apples, since the various types of logic used on a chip—GPU cores, cache, memory controllers, video decoders, etc.—have different densities, but at a high level Nvidia is putting 52 percent more transistors into 17 percent less space. That's a relative density improvement of over 1.8x.

As another example, the GA104 chip (which will be used in the RTX 3070) packs 17.4 billion transistors into 392.5mm square. Again, that's about 1.8x the transistor density of last gen. Alternatively, Nvidia's GA100 packs 54 billion transistors into an 826mm square using TSMC N7, which is nearly 50 percent more transistors per square mm. GA100 has plenty of other differences, but it's clear Nvidia used TSMC N7 for GA100 because it was the best "money is no object" choice for a data center class GPU.

There are some downsides to using Samsung 8N, however. The most obvious



The GeForce RTX 3090 packs in 24GB of GDDR6X memory into its tiny PCB.

NVIDIA AMPERE GPU SPECIFICATIONS

	RTX 3090	GeForce RTX 3080	RTX 3070
GPU Codename	GA102	GA102	GA104
GPCs	7	6	6
TPCs	41	34	23
SMs	82	68	46
CUDA Cores / GPU (FP32)	10,496	8,704	5,888
Tensor Cores / GPU (3rd Gen)	328	272	184
RT Cores (2nd Gen)	82	68	46
GPU Boost Clock (MHz)	1,695	1,710	1,725
FP32 TFLOPS	35.6	29.8	20.3
FP16 TFLOPS	35.6	29.8	20.3
INT32 TOPS	17.8	14.9	10.2
FP16 Tensor TFLOPS (FP16 Accumulate)	142 / 284	119 / 238	81.3 / 162.6
FP16 Tensor TFLOPS (FP32 Accumulate)	71 / 142	59.5 / 119	40.6 / 81.3
BF16 Tensor TFLOPS (FP32 Accumulate)	71 / 142	59.5 / 119	40.6 / 81.3
TF32 Tensor TFLOPS	35.6 / 71	29.8 / 59.52	20.3 / 40.6
INT8 Tensor TOPS	284 / 568	238 / 476	162.6 / 325.2
INT4 Tensor TOPS	568 / 1136	476 / 952	325.2 / 650.4
Memory Size and Type	24GB GDDR6X	10GB GDDR6X	8GB GDDR6
Memory Interface	384-bit	320-bit	256-bit
Memory Clock (Data Rate)	19.5Gbps	19Gbps	14Gbps
Memory Bandwidth (GB/sec)	936GB/s	760GB/sec	448GB/s
ROPs	112	96	96
Pixel Fill-rate (Gigapixels/sec)	193	164.2	165.6
Texture Units	328	272	184
Texel Fill-rate (Gigatexels/sec)	566	465	317.4
L1 Data Cache/Shared Memory	10,496KB	8,704 KB	5,888 KB
L2 Cache Size	6,144KB	5,120 KB	4,096 KB
Register File Size	20,992KB	17,408 KB	11,776 KB
Total Graphics Power (TGP)	350 Watts	320 Watts	220 Watts
Transistor Count	28.3 Billion	28.3 Billion	17.4 Billion
Die Size	628.4mm^2	628.4mm^2	392.5mm^2
Manufacturing Process	Samsung 8N	Samsung 8N	Samsung 8N

© NVIDIA

is power requirements. The GeForce RTX 3080 has a TGP (Total Graphics Power) rating of 320W, which is the highest single-GPU graphics card power level we've seen. The RTX 3090, meanwhile, bumps the TGP to 350W. Nvidia claims that the Ampere architecture is up to 1.9x the performance per watt of Turing, but how it derives that number is a bit tricky.

If you take an unspecified Turing GPU and an unspecified Ampere GPU and run both at the same performance level, Turing would require 1.9x more power. However, the retail Ampere GPUs are pushing the design to its limits, and as you move to the right on the voltage/frequency curve, efficiency is greatly reduced. In our testing, looking at real-world fps/watt, the RTX 3080 FE is about 33 percent faster than the RTX 2080 Ti and uses about 24 percent more power. That's a net improvement, but nowhere near 90-percent higher efficiency. The high TGP also means that Nvidia and its partners will have to put more effort into designing high-performance cooling solutions, which explains the far larger cooler designs in general.

Core Benefits:

FP32 Times Two

With the lithography appetizer out of the way, let's dig into the real meat of Ampere. Nvidia's basic design structure remains similar to Turing, in that each GPU has clusters of GPU cores called SMs, which are then grouped into GPCs. Each GPC also has one TPC (Texture Processing Cluster), and then there are memory controllers, a video decoding block, caches, and other miscellaneous parts. Let's run through each of those.

WHAT ARE TFLOPS?

One of the base measurements of GPU performance is TFLOPS, or teraflops. What is a teraflop? It's 1 trillion "Floating-point Operations Per Second." Think about that for a moment. How long would it take you to add or multiply two numbers, like π (pi) and e (Euler's number)? We'll be nice and let you round off to just 3.14159 and 2.71828. Let us know when you're finished—you can even use a calculator if you want. If you have a modern graphics card, it could do that same sort of calculation anywhere from 10 trillion to 30 trillion times per second.

At its basic level, computer graphics involves math—lots and lots of math. So much math that those trillions of multiplications and additions can actually be put to good use. A lot of the calculations are matrix operations, used to manipulate and project a 3D object onto a 2D plane like your PC's display. That specific type of workload often involves multiplying two matrices and then adding a third matrix to the result, so GPUs have a special operation called FMA: Fused multiply-add.

Each FP32 graphics core can execute one such FMA each clock cycle, so to get TFLOPS you take the number of "cores" times the clock speed, times two. And that's where you get TFLOPS. Related to this is a secondary metric, TOPS—teraops. This is used when the workload isn't floating-point, so INT32, or even INT8 or INT4.

Nvidia's Turing and Ampere architectures don't just have CUDA cores, however. There are also Tensor cores, which are even more optimized to do massive amounts of math. On Turing, each Tensor core could do a 4x4x4 matrix FMA each cycle. That's 128 FLOPS per Tensor core. The catch is that the Tensor cores use a lower-precision FP16 (16-bit floating-point) format, and they're not tuned to do all the graphics calculations that the regular cores can handle. Ampere ups the ante with 8x4x4 Tensor core calculations, so twice the FP16 throughput for Tensor operations. Ampere also uses the Tensor cores for fast math (FP16) GPU calculations, but only at the same rate as the GPU FP32 cores.

The SM (Streaming Multiprocessor) is the main workhorse, and it's gone through various configurations over the years. Each SM has four processing blocks, which can dispatch up to 32 threads per clock (two 16-thread wavefronts). Turing had 64 FP32 (32-bit floating-point) CUDA cores per SM, plus 64 more cores for INT32 (32-bit integer) calculations, and both could be utilized concurrently. Pascal had 128 FP32/INT32 cores only—the cores could only do one or the other data type at a time. With Ampere, Nvidia builds off the Turing design while at the same time shifting a bunch of things around.

First, Nvidia sort of doubled the number of FP32 CUDA cores per SM, but it did this by adding FP32 functionality to the previous INT32 datapath. So now, Ampere has 64 dedicated FP32 cores in an SM, and then 64 FP32/INT32 cores. It can still do concurrent FP32 + INT32, just like Turing, but alternatively it can do FP32 + FP32. That means for the right workloads, Ampere has more than double the theoretical performance of Turing. (See boxout on TFLOPS.)

This has interesting ramifications for different workloads. Take a game where the instruction mix is roughly 65 percent FP32 and 35 percent INT32—according to Nvidia, this is roughly how the average game behaves, with INT32 used for memory address calculations, texture lookups, and other less complex math. On Turing, the FP32 datapath would have ended up fully utilized, while the INT32 datapath would have only been about 50 percent utilized. With Ampere, the dedicated FP32 cores are fully utilized, but now the FP32/INT32 cores are split roughly 30/70 on FP32 vs. INT32 work.

Best-case, the RTX 3080 is theoretically 2.95x faster than the RTX 2080 at FP32 workloads. In practice, however, it is more like up to twice as fast in actual gaming performance.

Are You Feeling A Little... Tensor?

Ampere packs in four 3rd-generation Tensor cores per SM while Turing included eight 2nd-generation Tensor cores per SM. (Incidentally, 1st-gen Tensor cores were only present in the Volta architecture, which showed up in the Titan V as well as supercomputer V100 GPUs.) That means the RTX 3080 has 272 Tensor cores, compared to 368 Tensor cores in the RTX 2080. As noted in the TFLOPS discussion, however, the Tensor operations are now done on 8x4x4 matrices instead of 4x4x4 matrices, which means that each Ampere Tensor core is twice as fast as a Turing Tensor core. But that's not all.

Tensor cores are useful for deep-learning applications, where various matrices are frequently multiplied to determine new weights over time. The most important elements end up with higher weights, while elements that are deemed unimportant often end up with a weight of zero. What's zero times, well, anything? Zero! We like easy math. But if a Tensor core is doing lots of zero multiplications, that's pretty much wasted effort.

Ampere introduces fine-grained sparsity support, which allows tensor operations to basically skip all those zeroes and get to the important stuff. Nvidia claims that with sparsity enabled, on algorithms that benefit from the feature (which isn't everything), the performance is twice as fast. So, with sparsity enabled, each Tensor core in Ampere is potentially four times as powerful as in Turing.

Beyond just boosting FP16 performance, the 3rd-gen Tensor cores also gain support for new data types: BF16, TF32, INT8, and INT4. These can be useful in certain deep-learning

NetEase Games
RTX ON

Ray-tracing performance should improve significantly.

© NVIDIA, NETEASE GAMES

workloads, for different purposes. BF16 is an alternative floating-point format with a 7-bit mantissa and 8-bit exponent (compared to FP16's 5-bit exponent and 10-bit mantissa). TF32, meanwhile, is an FP32 alternative that has the same 8-bit exponent but only a 10-bit mantissa (compared to a 23-bit mantissa for FP32). BF16 performance is equal to FP16 performance, while TF32 performance is half the FP16 rate.

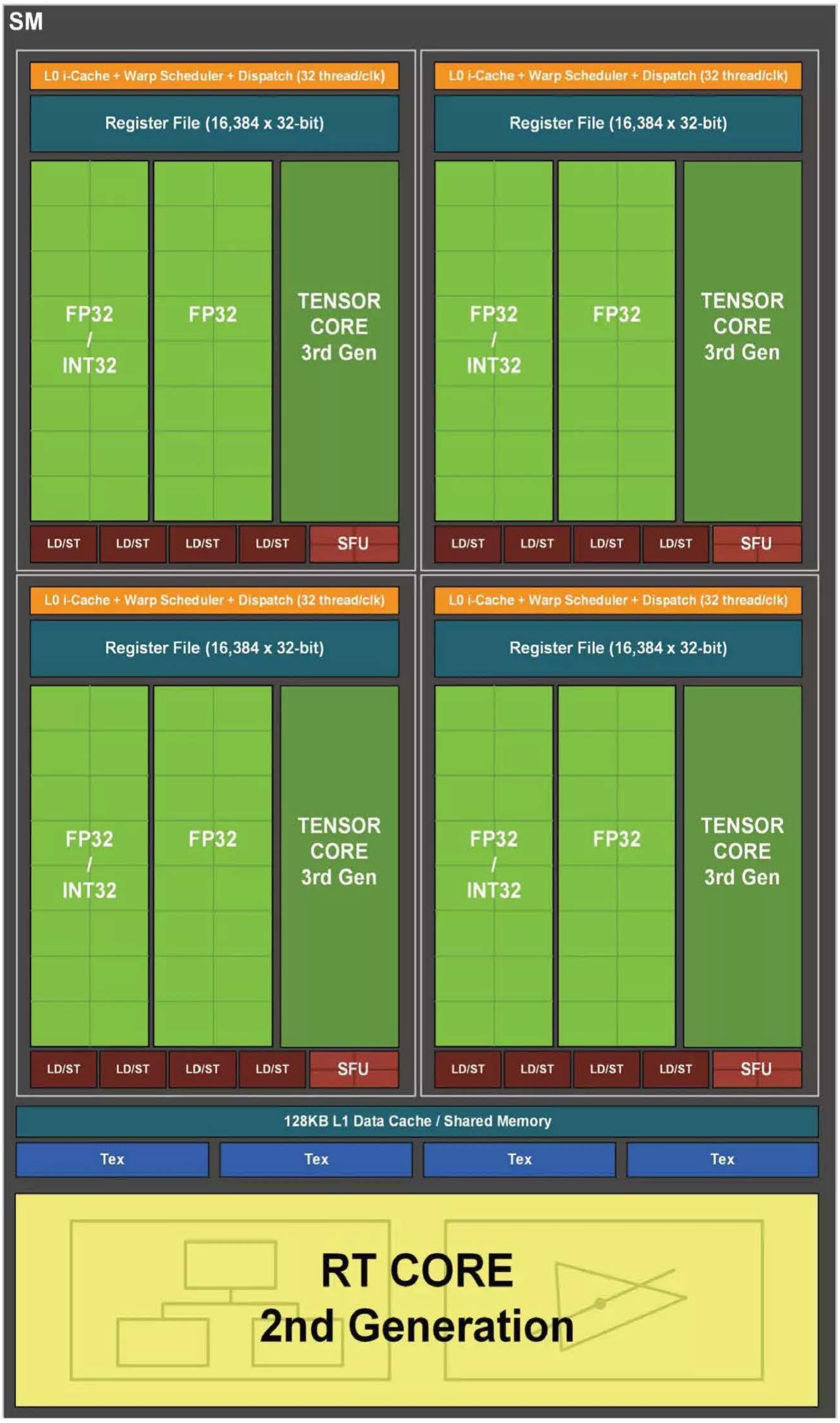
The INT8 and INT4 data types (8-bit and 4-bit integers) are more for inference. INT8 are half the size of FP16, so they're twice the throughput—up to 238 TOPS with the RTX 3080, and 476 TOPS with sparsity. INT4 doubles those values yet again. These may not end up mattering much for gaming workloads, but deep learning is one of the fastest growing areas of research right now, so there's a lot of potentially groundbreaking ideas that could benefit in the future.

Even Faster Ray Tracing

Last but not least, Nvidia also boosted the ray-tracing performance of Ampere. It wasn't willing to go into a lot of details—AMD and Intel are still trying to figure out the optimal way to do ray tracing in GPUs, and Nvidia doesn't want to provide any hints—but Ampere's RT cores are up to twice as fast on ray-triangle intersection calculations, and overall Nvidia claims that the 2nd-gen RT cores are 1.7x faster than Turing's 1st-gen RT implementation. As before, there's one RT core per SM.

The new RT cores have also learned a few tricks. The biggest involves adding a "time" element to ray-tracing calculations, which can dramatically improve performance in motion-blur effects. Not everyone likes motion blur in games, but it's quite important in films where the on-screen results can look choppy compared to traditional film techniques that inherently capture motion blur. With the new "time stamp" addition, Ampere can be even more of an improvement over Turing in rendering accurate motion blur.

The RT cores can also run concurrently with the shader cores on Ampere, which means running a ray-tracing workload doesn't inherently cause other work to stall out for a few cycles.


SM
L0 i-Cache + Warp Scheduler + Dispatch (32 thread/clk)
Register File (16,384 x 32-bit)
FP32 / INT32
FP32
TENSOR CORE 3rd Gen
LD/ST
SFU
128KB L1 Data Cache / Shared Memory
Tex
RT CORE 2nd Generation

The Ampere architecture doubles down on FP32, Tensor, and RT core performance.

© NVIDIA

GDDR6X:
Thanks for the Memories

All of the Turing GPUs used GDDR6 memory, mostly clocked at 14Gbps (with a few budget and mainstream GPUs clocked at 12Gbps, and the RTX 2080 Super clocked at 15.5Gbps). For Ampere, Nvidia has partnered with Micron to create a new GDDR6X memory standard. This is very similar to what we saw with GDDR5X on the previous Pascal-generation GPUs.

Micron has GDDR6X memory rated at 19-21Gbps, with the 3080 using 19Gbps memory and the 3090 using 19.5Gbps memory. The RTX 3070, meanwhile, sticks with 14Gbps GDDR6 memory, though GA104 can support GDDR6X as well (i.e., for a future RTX 3070 Ti, maybe). Memory configurations have also changed. The 3090 takes over the Titan RTX slot and gets 24GB of memory and a 384-bit bus, for a total bandwidth of 936GB/s. The RTX 3080 has 10GB on a 320-bit bus, for 760GB/s of bandwidth. RTX 3070 is the less impressive solution, matching the previous-generation 2080 down to 2060 Super with "only" 448GB/s. Nvidia has changed other aspects of the architecture to help make better use of the memory bandwidth, however, so raw bandwidth alone doesn't tell the full story.

One new addition is EDR: Error Detection and Replay. This is a cheaper alternative to ECC (Error Correcting Code)

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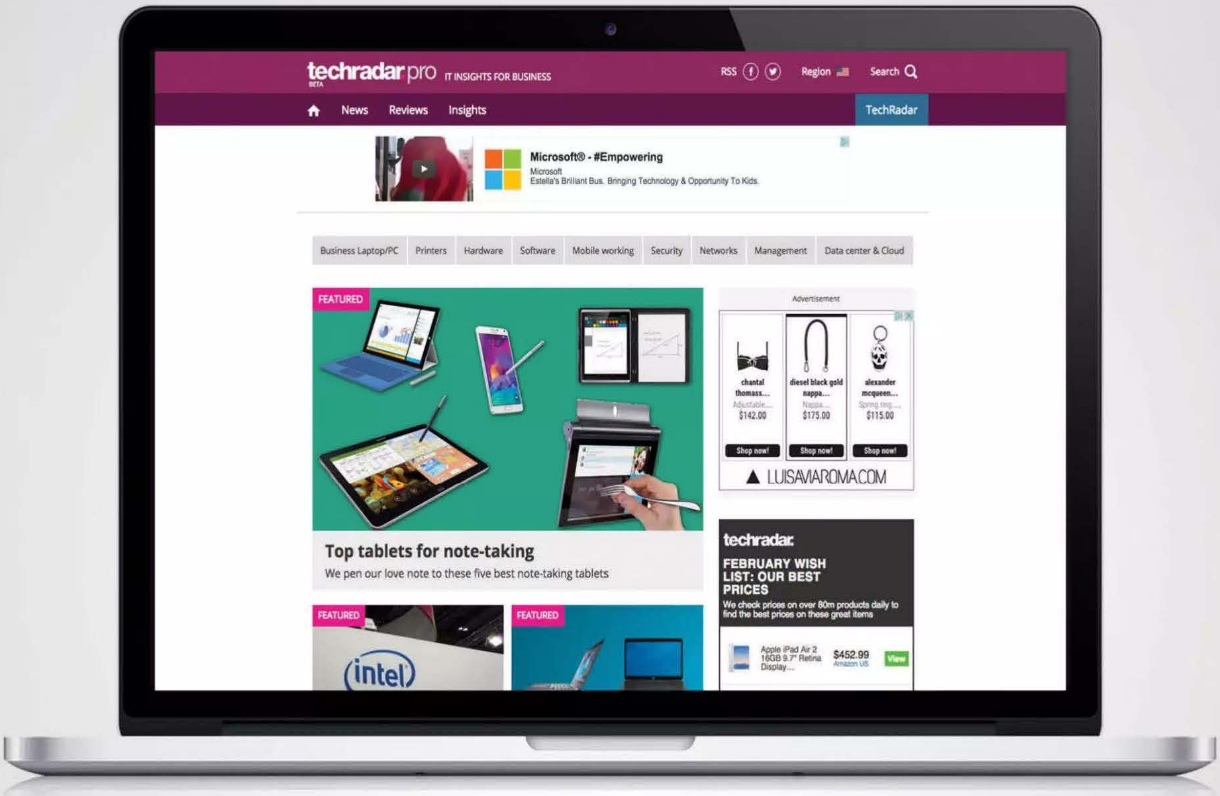
IT INSIGHTS FOR BUSINESS



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and enables the GPU to recover from errors in data transmission. If the memory subsystem detects a transmission error, it simply retries until it succeeds. This potentially allows for higher clocks that actually have lower performance, but it does mean that running close to the limit of the memory won't be as likely to crash on infrequent errors.

While we're on the subject of memory, let's also note that the ROPs (Render Outputs) have been shifted out of the memory controllers and into the GPCs (Graphics Processing Clusters). This provides more flexibility, enabling Nvidia to have 96 ROPs on both the 3070 and 3080 even though the latter has two additional memory chips. That's because the GA102 has up to seven GPCs of 12 SMs (Streaming Multiprocessors) each, and the 3080 has six GPCs enabled. The GA104, meanwhile, has six GPCs of only 8 SMs each.

Something else to keep an eye out for is future higher capacity RTX 3080 and 3070 configurations. The scuttlebutt is that Nvidia is waiting for AMD to reveal its RDNA 2 / RX 6000 lineup, which is expected to have 16GB on the top RX 6900 XT model. Then Nvidia will announce an RTX 3080 20GB card that costs $100 more than the RTX 3080. That may end up being just a rumor, but at least one manufacturer part list leaked with 20GB and 16GB RTX 3080 and 3070 cards listed.

Cache, Shared Memory, PCIe Gen4, and a Farewell to SLI

Wrapping up the Ampere architecture, Nvidia also increased cache sizes and added more flexibility to the shared memory, so that it can be configured as varying amounts of L1 cache or shared memory. The L2 cache on the 3080 is 25 percent larger than on the 2080, and the L1 cache and shared memory capacity is 33 percent larger. Both of these changes improve overall memory throughput.

All of the Ampere GPUs are also fully PCIe Gen4 compliant. In practice, it doesn't currently appear to make much difference, especially since the only PCIe Gen4 consumer platforms come from AMD. Intel CPUs are still generally faster for gaming, so until Intel catches up (with Rocket Lake and Alder Lake on desktops), most gamers will still be better off pairing Ampere with a PCIe Gen3 solution.

Finally, Nvidia has all but killed off SLI with Ampere. The RTX 3090—yes, the $1,500 GPU—is the only consumer card that will support NVLink and SLI this round. The NVLink bandwidth has been doubled, however, meaning your Turing NVLink connectors are now outdated. So, $3,100 will get you a pair of 3090 cards with the new NVLink... and then you're still dependent on game developers to support SLI.

That's because Nvidia has explicitly made SLI support a developer choice, and as we've seen over the past few years, that means SLI is basically dead. Note that multi-GPU isn't affected, so GPU compute workloads like Folding@Home will be fine.

Pump Up the Amperes

As you can tell with this short—if you can believe that—overview, Ampere is a tour de force for Nvidia. Check out the specs tables, and any enthusiast is likely to start drooling. With Nvidia's cards on the table, we now get to see if AMD can follow suit or maybe even snag a pot or two. We should know more about AMD's plans by next month.

Ultimately, all of these architectural changes only matter so much. Eventually, we need to run games and benchmarks to see how Ampere stacks up in the real world. We've done just that with our RTX 3080 review. Spoiler alert: It's damn fast.

We're left wondering where Nvidia will go next. We've known about the Ampere codename since before Turing launched—and in fact, many thought we were getting Ampere two years ago instead of Turing. But looking forward, our crystal ball is very cloudy. We don't know the codename for Nvidia's post-Ampere GPUs. We also don't know what process technology Nvidia will use.

TSMC's N7 might be better than Samsung 8N, but even better than N7 is N7P, N7+, N6 (with EULV), and the new N5 (which just started cranking out Apple's A14 silicon). Will Ampere stick around for two years on 8N, or could it be a shorter-lived architecture, with a die shrink to a more advanced 5nm node? We don't know, but hopefully we don't have to wait two years and add another 100W to find out.

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8K GAMING WITH DLSS 2.1

Ampere adds support for HDMI 2.1, which provides up to 48Gbps of bandwidth. It also has DisplayPort 1.4a, which only has 32.4Gbps of bandwidth. Neither one has enough bandwidth to do 8K (7680x4320) at 60Hz without compression, but both can use DSC to spit out 8K60 with HDR. That's still four times as many pixels as 4K, which means even on a 3090 it's still going to be a problem. Enter DLSS 2.1.

DLSS 2.0 has three modes: Performance (4x scaling), balanced (3x scaling), and quality (2x scaling). Even with performance mode, DLSS would need to scale a 4K signal to 8K—it could probably do it, but 8K upscaling is going to be more demanding than 4K upscaling. The solution: DLSS 2.1 adds a new ultra-performance mode with 9x scaling. Specifically, for 8K rendering, DLSS ultra performance renders at 2560x1440.

Obviously, upscaling by a factor of nine is not going to result in perfect image quality. But the bigger question is: On an 8K display, could you even tell? As far as bragging rights go, however, an 8K TV with a 3090 GPU has to be at the top of the gaming enthusiast hierarchy.

TECH PORN

PERFORMANCE GEAR LAID BARE

1 BACKUP CENTRAL

The Home Duo houses support for Windows Backup, macOS's Time Machine, and your phone's camera roll too, regardless of OS.

16TB WD My Cloud Home Duo NAS

IN OUR GRAND BELOVED PASTIME, the genius of human brilliance has perpetually brought us up above and beyond anything we could've possibly imagined. We can process unfathomable calculations almost as fast as the speed of light, render entire worlds and digital realms in fractions of a second, and blaze through masses of stored data in the time it takes to blink.

And yet, for all our advancements and perpetual brilliance in pushing the boundaries of that humble transistor, it has come at a price. This eternal pursuit to improve what our machines are capable of, no matter the cost, has mired this technological landscape, and marked it with one fatal flaw, in perhaps a way that we've yet to truly fully appreciate.

The nature of how we store things has become volatile, weak, vulnerable. We have moved our cherished data and memories far away from those faithful spinning platters, into more compact, faster, and far more disruptive flash memory devices. Or worse still, handed it over to big corporations, who ominously secure it all within a vast array of cloud servers.

Many of us now rely solely on flash memory to power our systems. A cheap 1TB PCIe 3.0 SSD here, a high-capacity SATA drive there, and all of a sudden, those HDDs of yesteryear are long gone. But that new solution presents its own problems. By its very nature, flash memory decays over time, as the electrons holding the data within those cells lose their charge. Inevitably, the disk will die, and we're forced to either move data onto a new drive or forever lose it to the void. As speeds have increased we have sacrificed longevity and advancements in capacity.

But it doesn't have to be that way. Perhaps it's time to invest in a NAS, a long-serving device with 16TB of hard drive storage in RAID1, and a gigabit Ethernet port to hook up to your router. Perhaps it's time we saved today, so we can remember yesterday. **–ZAK STOREY**

2 TRUE CAPACITY?

You can get up to 16TB of capacity, but this comes with a caveat: By default the NAS is set up in RAID1. This helps protect it long term in case of single individual drive failure, but does mean that you lose half that advertised storage.

3 SMART HOME COMPATIBILITY

Whether it's Sonos streaming, Plex, or Google Chromecast, if you've got a decent, modern device, then the likelihood is that you can stream from the Home Duo directly to it.

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HOW TO

STEP-BY-STEP GUIDES TO IMPROVING YOUR PC

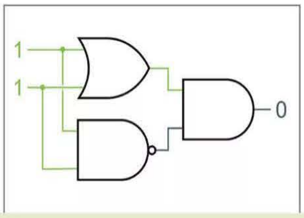
TIP OF THE MONTH

PHANTEKS
UNIVERSAL FAN CONTROLLER
MANUAL

TRY OUT A FAN HUB

PC a bit noisy? Fans not ramping up enough to keep it cool? Then you may want to invest in a fan controller to mount inside your case. Plenty of manufacturers (such as Phanteks, NZXT, or Deepcool) offer these, enabling you to take more direct control over your PC's fans—whether that's through dedicated software, or a physical controller for those of you who prefer more tactile controls.

MAKE – USE – CREATE



52
Discover how to design your own microprocessor

58
DIY custom sleeving Part 1— tool up

60
Nvidia's Ampere architecture meets RGB overkill

© PHANTEKS

CHRISTIAN GUYTON
STAFF WRITER

PRE-ORDER PANDEMONIUM

Well, it certainly was fun to watch almost every major gaming manufacturer and retailer devolve into utter chaos over pre-orders in September. It's almost staggering how much went wrong. PS5 pre-orders were first on the chopping block, with insufficient stock triggering an apology from Sony. And that, well, never happens. Confusion over console names could spell trouble for Microsoft, and suppliers of Nvidia's spicy new GPUs immediately ran into pre-order stock problems.

Obviously, the COVID-19 outbreak has wreaked havoc on production and distribution, but it begs the question as to why the next generation of gaming platforms wasn't delayed until a proper launch could be conducted. Nobody seems prepared: Titanic launch titles like *Halo Infinite* have been pushed back, while prices were obfuscated until the last possible moment in the most frustrating game of chicken ever played by tech corporations.

But now that the RTX 3000 cards are on the market and blowing the competition away, online PC journalists are pouncing on SEO opportunities with pre-order guides as I write this, and I'm always happy to see my fellow writers flourish. No matter how the industry messes things up, we're certainly a tenacious bunch.

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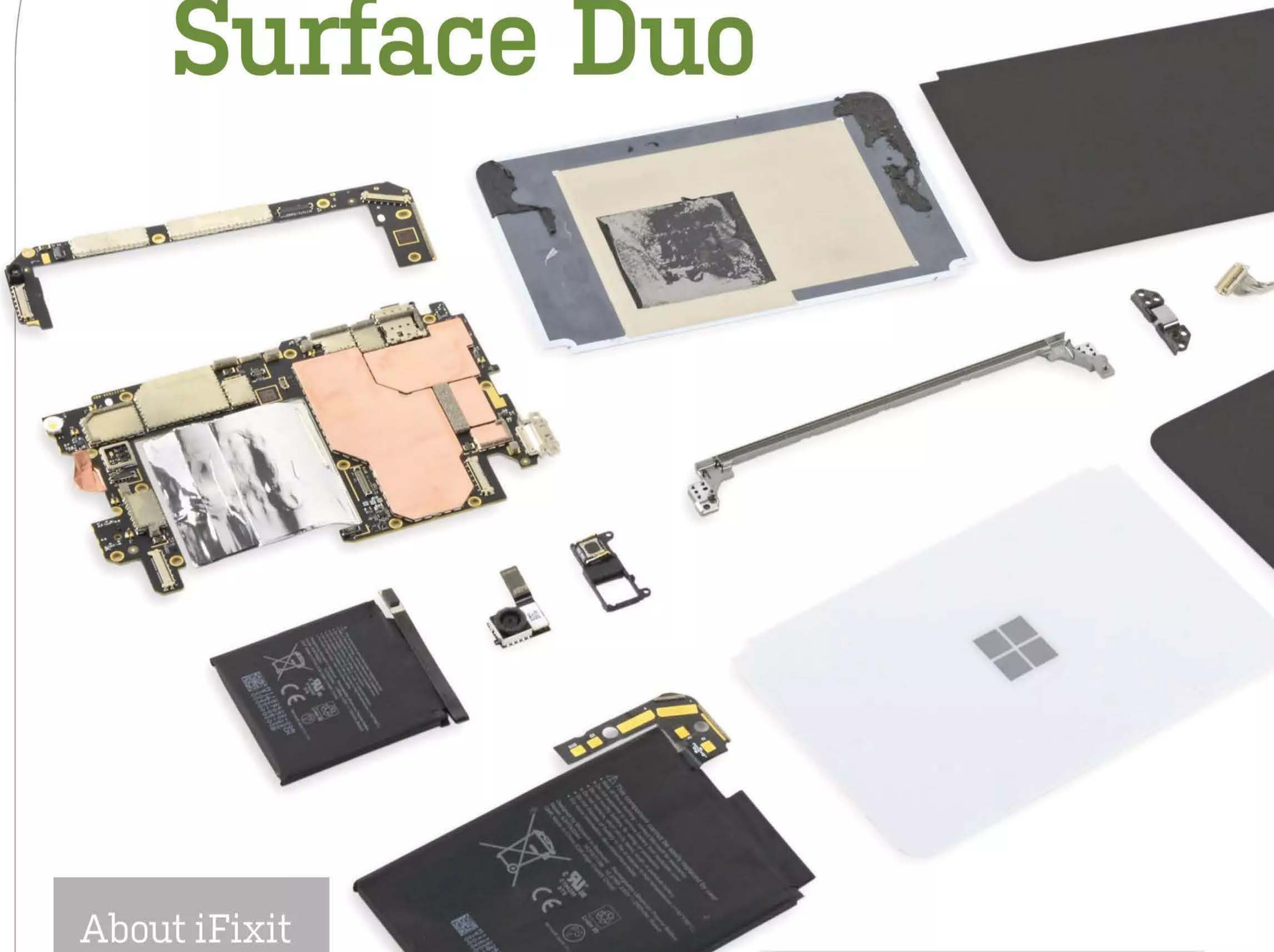
AUTOPSY

THIS MONTH WE DISSECT...

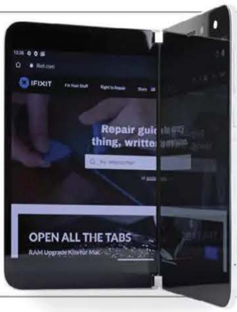
Microsoft Surface Duo



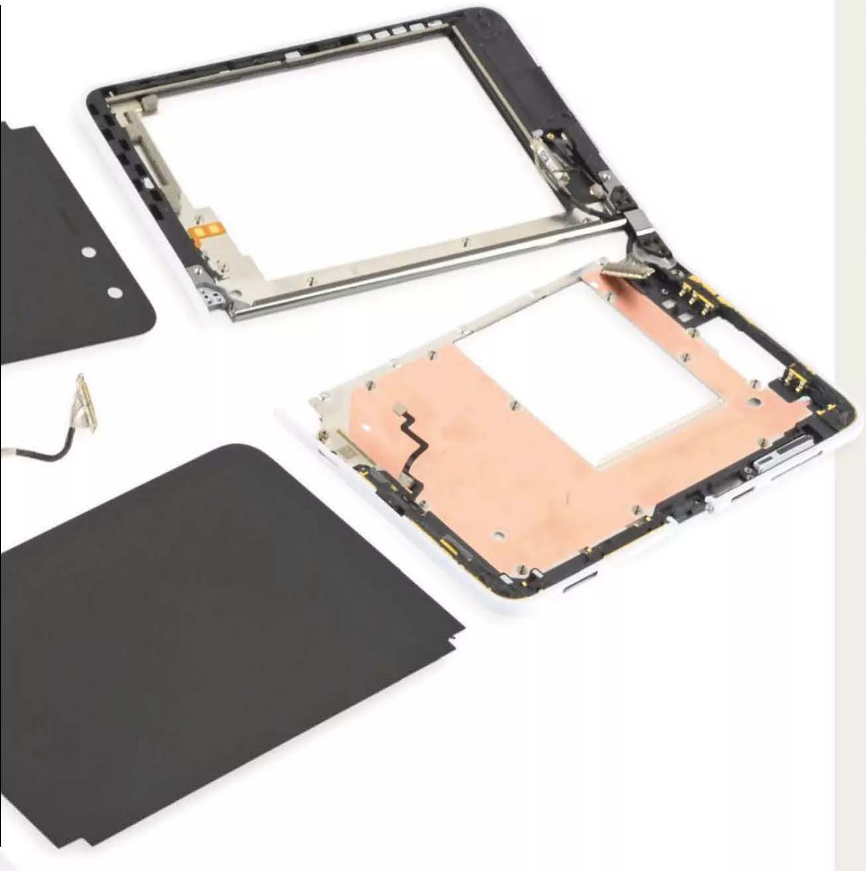
About iFixit

iFixit is a global community of tinkerers dedicated to helping people fix things through free online repair manuals and teardowns. iFixit believes that everyone has the right to maintain and repair their own products. To learn more, visit www.ifixit.com.

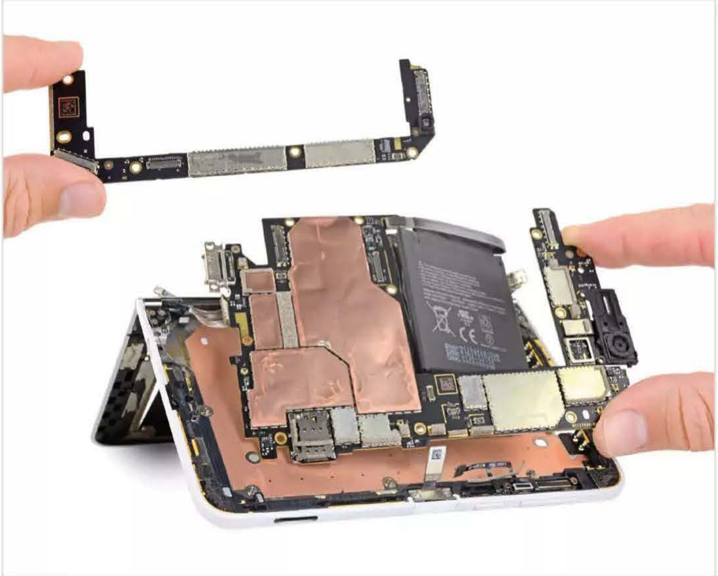
When prying the displays off, be careful not to damage them.



Unfolded, this "not a phone" is super thin—just 4.9mm. For comparison, the famously so-thin-it-bends iPhone 6 Plus was 7.1mm.



A combination of a ton of glue and fragile ribbon cables makes this tricky to disassemble.



BACKGROUND

Microsoft reportedly worked on the Surface Duo for six years. We can probably tear it down in less time than that, but with any brand-new form factor, there are no guarantees. Here's hoping the Duo boasts the repairability of recent Microsoft sequels like the Surface Laptop 3 or the Surface Pro X.

MAJOR TECH SPECS

- Two 5.6" AMOLED displays (each 1800 x 1350, 401 PPI)
- Two batteries working in tandem, totalling 3,577 mAh
- A Qualcomm Snapdragon 855 SoC paired with 6GB of DRAM
- 128GB or 256GB Internal Flash Storage
- A 11 MP f/2.0 camera, optimized for both front and rear use
- WiFi-5, Bluetooth 5.0, 4x4 MIMO LTE, and USB-C 3.1 connectivity hardware

KEY FINDINGS

- It's a non-phone, but the Duo has a removable SIM like other Surface devices. When folded, it undercuts Samsung's original Fold by 7mm (9.8 mm vs the Fold's 17mm).
- The Duo's entire left half bears a striking resemblance to a miniature iPad—big battery, with a sliver of circuit board snaking around the right side. The right half looks like nothing we've seen—it's almost a solid wall of circuit board, with a little window in the middle for the second battery.
- Opening pick, meet chassis gap. No heat or suction cups necessary yet! This is way too good to be true. And it is. We quickly get bogged down in adhesive and break out the heat gun. Complicating matters, the panels are booby-trapped. Both batteries are stuck to their respective rear panels, and tethered to the rest of the phone via fragile cables. Careful carving through graphene cooling sheets and sticky strips of adhesive does the trick, but we nearly destroy a flex cable that houses some indicator LEDs and connects the earpiece speaker to the circuit board nearby.
- The Duo's hemispheres are connected by two multi-strand interconnect cables routed through the hinges. They remind us more of old-school MacBook display cables than the flat ribbon cables we've seen in other hinges. We're hopeful that this style of cable will be able to hold up to a lot of abuse.
- As for battery replacement. Obstacle 1: Glue. Lots. Obstacle 2: Tri-point screws. Obstacle 3: One battery's connector is pinned underneath the mobo. As is often the case with Microsoft, it seems like the only way to kill power is to remove the board completely, making any repair a short circuit waiting to happen. It seems like Microsoft had no thoughts of battery replacement. $1,400 is a lot to shell out for a device, let alone one with a built-in death clock.
- Next we twist away tons of Torx screws securing the spine and hinges. The two big wings are free to fly away from the central spine. These frames provide a lot of the device's structure and torsional rigidity, helping the two halves open evenly, and provide mounting points for most of the internals.
- Repairability Score: 2 out of 10 (10 is easiest to repair). Displays and back glass covers can be replaced without disassembling other components. Batteries are glued and require extensive disassembly to service. The USB-C port is soldered to the main board. Tri-point screws secure key components. OLED panels are not well protected from prying, yet must be removed for most repairs. Stubborn glue at all entry points complicates any repair attempt.

Design Your Own Microprocessor

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MOST LIKELY, the processor in your PC has upwards of a billion transistors. Trying to get your head around the workings of such a complicated electronic circuit might, therefore, seems a daunting task. Yet helping you to understand what goes on inside a CPU is the task we've set ourselves here. The latest chips are complicated by many bells and whistles doing way more than straight "processing", so we should think of a very basic chip and take it on trust that the principles here can indeed be scaled up.

In 1971, the very first microprocessor—the 4-bit Intel 4004—still had 2,250 transistors on board. While that might be a whole lot more manageable than a couple of billion, it might still seem to be no mean feat to understand how that worked from an electronics viewpoint.

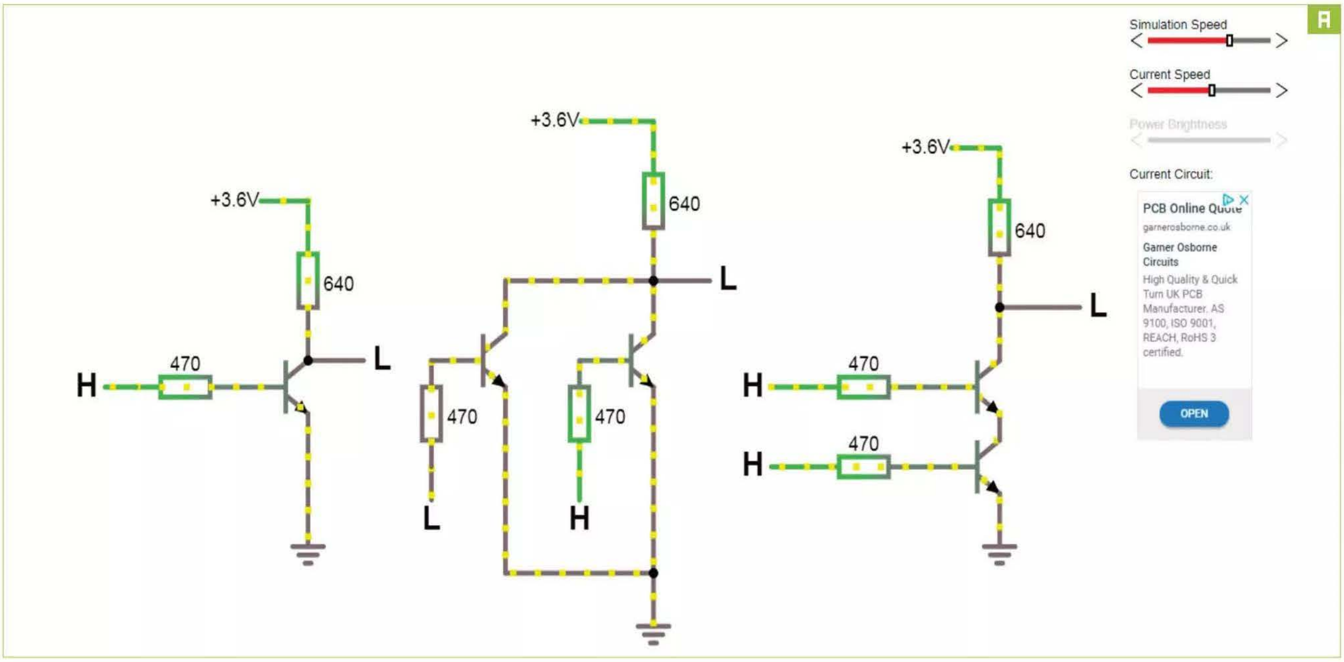
But that this isn't nearly as difficult to understand as you might fear. The fact is that logic circuitry is created in a so-called bottom-up approach. Transistors—the fundamental electronic building block—are used to create logic gates, which are the fundamental logic building blocks. From this point on, we can forget about transistors and see how logic gates can, in turn, be used to create more complicated logic building blocks such as decoders and multiplexers. In the next stage, these are used to create even more complicated logic elements, and this continues until we finally end up with a complete CPU. Nowhere in this process will we see more than a handful of transistors or a similar number of logic gates—what could be easier? **–MIKE BEDFORD**

1 LOGIC GATES

The bottom-up approach might make it easier to understand complicated logic circuitry, but learning about it with real hardware would still be a major undertaking. After all, since each transistor has three leads, and because components other than transistors are also needed, building even a basic microprocessor—like the Intel 4004 with its 2,250 transistors—would require many thousands of soldered connections. There's got to be an easier way, and there is: Simulation. Here we're going to use two simulators, one that works at the level of electronic components, such as transistors and resistors, and one that operates with logic elements.

» First of all, we're going to use an electronic circuit simulator to see how logic gates are created. It's an online utility that runs in your browser. You can find it at www.falstad.com/circuit and it's free to use. We suggest you select the full-screen view before continuing. You can define your own circuits in the simulator, but it also includes lots of sample circuits that you can try. In particular, you can find circuits for three of the most fundamental logic gates—the inverter, the NOR gate, and the NAND gate—at "Circuits → Logic Families → RTL" and then "RTL Inverter, RTL NOR and RTL NAND." As you can [Image A], we've copied and pasted them so they appear together on screen, and simplified the NOR and NAND gates by changing them from having three inputs to two.

» On the display, the letters H and L, which are shown next to the inputs and outputs, refer to high voltage and



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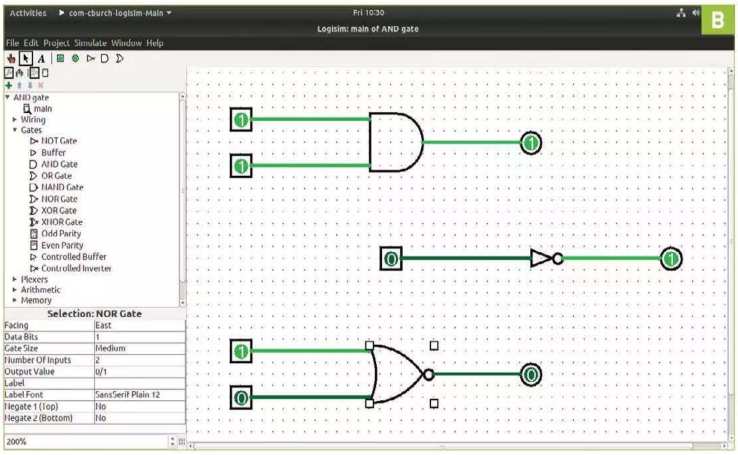

Selection: NOR Gate

Facing	East
Data Bits	1
Gate Size	Medium
Number Of Inputs	2
Output Value	0/1
Label	
Label Font	SansSerif Plain 12
Negate 1 (Top)	No
Negate 2 (Bottom)	No

low voltage—in this case 3.6V and 0V respectively, which relate to binary one and zero. This is reflected throughout the circuit by coloring wires at the high voltage in green, and those at the low voltage in gray. Moving yellow dots indicate that a current is flowing in a certain wire.

›› Let's look at the inverter. When it first appears, the input is H, but to start, click it to change it to an L. Because there is no positive voltage at the transistor's base—that's the left-most of its three terminals—it's turned off in this state, which means that no current flows from its collector (top terminal) to its emitter (bottom terminal). As a result, the output is high because it's connected to 3.6V via the 640 ohm resistor. Click the input again to change it back to an H. Now the transistor is turned on and, as a result, a current flows between the transistor's collector and its emitter. The output is, therefore, effectively connected directly to 0V (the triangular three-line "ground" symbol), so it becomes low. The circuit outputs an L when the input is H, and vice versa. Putting this in logic terms, it generates a 0 from a 1 and a 1 from a 0, which is the function of an inverter.

›› Moving on to the other two circuits, a NOR gate means "not OR" and a NAND gate means "not AND." These can be thought of as OR and AND gates with an inverter connected to their outputs, even though they're not actually implemented that way. We trust that, as you start to play with them, it should be fairly obvious to see how they work. Slightly altered versions of these circuits, with the resistor in the emitter circuit instead of the collector circuit, can be used to implement the OR function and the AND function, which can be thought of as more fundamental than the NOR and NAND functions.

2 EXPERIMENTING

Although the circuit simulator includes a few logic elements among its basic components, to go much further we need to turn to a more fully featured logic simulator, so we'll use Logisim (www.cburch.com/logisim) [**Image B**], which runs locally under Linux. We're not going to provide blow-by-blow instructions of how to use Logisim, because there is a user manual—however, a few tips are appropriate.

›› To test out the various circuits that we're going to investigate, you'll generally need to connect something to all the inputs so that you can toggle them between a 0 and a 1, and connect something to the outputs to indicate whether it's a 0 or a 1. Both these requirements are fulfilled by a component called Pin, which can be found under Wiring. When you select a component to add to the circuit, a table appears that shows—and enables you to alter—that component's attributes.

›› The Pin component has an attribute called Output?, the meaning of which is ambiguous. Selecting "Yes" doesn't make it an output but instead makes it something you'd connect to an output to indicate its logic state. Similarly, selecting "No" makes it something that you'd connect to an input to define its logic state. The shape changes with this selection, so remember that you connect squares to inputs and circles to outputs. Note also the Facing attribute, which is East by default, but which you'd normally want to alter to West for Pins when Output? is set to "Yes."

›› Note also that in addition to the 0 and 1 labels on the input and output pins, wires are colored dark green (almost black) to indicate 0, and light green to indicate 1. These aren't the most intuitive of colors, but there's no way of changing them, and we're confident you'll soon get used to this color coding. Finally, to change the state of a Pin attached to an input, select the mode that allows values in the circuit to be changed by first clicking the pointing figure icon at the top left. Then just click the pin and you'll see it toggle between a 0 and a 1.

›› Annoyingly, however, we sometimes found the change wasn't actually implemented without first returning to the editing mode by clicking the arrow icon. Note that, if you'd prefer, you can use a LED instead of an output pin to indicate the state of an output. You'll find it under "Input/Output," and it's colored gray for a logic 0, changing to red for a logic 1.

›› To start, and to get a feel for the package, we suggest that you simply try out the basic logic gates: That's the inverter, plus the AND, OR, NAND, and NOR gates. Although the symbols are different, and they now appear as single components instead of collections of transistors and resistors, you'll find that they work as expected. The default number of inputs for gates is 5, but this can be changed in the attribute table—we suggest you select 2. Note also that the Three-state? attribute should be set to "No." Indeed, if present in the attribute table, you should select this option for any components

GATES FROM GATES

In our look at the various types of logic gates, we restricted ourselves to gates with two inputs. However, you'll remember that the sample gates in the online simulator initially had three gates, but we removed some of the circuitry to turn them into 2-input gates – and we also saw that Logisim gates have an attribute that defines the number of gates, from 2 to 32. The fact is that logic gates can have any number of inputs, and this can be achieved at the level of transistors—or, if you only have 2-input gates, you can work at the level of logic elements, connecting those gates together to produce gates with more inputs in various ways. For example, two 2-input OR gates can be used to create a single 3-input OR gate.

Although our circuits for decoders and multiplexers used both AND gate and OR gates, just one of these two gates can be used, in conjunction with inverters, to create the other. This being the case, you can get away with just the one type of gate plus an inverter to create any other logic building blocks. Here's an experiment you could try, either in Logisim or just as a pencil and paper exercise.

Take a 2-input OR gate and connect inverters to both its inputs and output. Now see what output you get for each combination of inputs. You'll find it has become an AND gate. Doing the same with an AND gate generates an OR gate.

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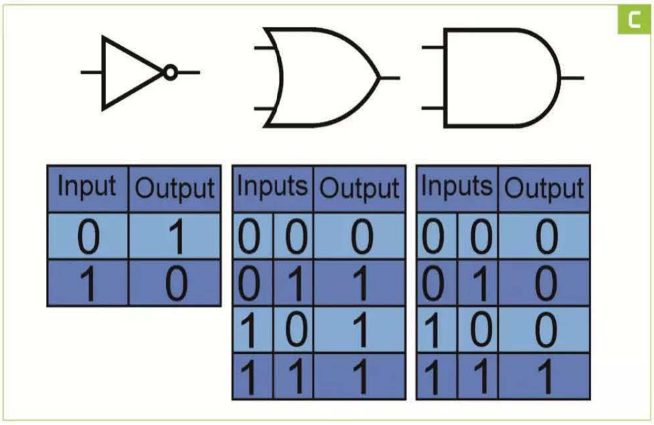
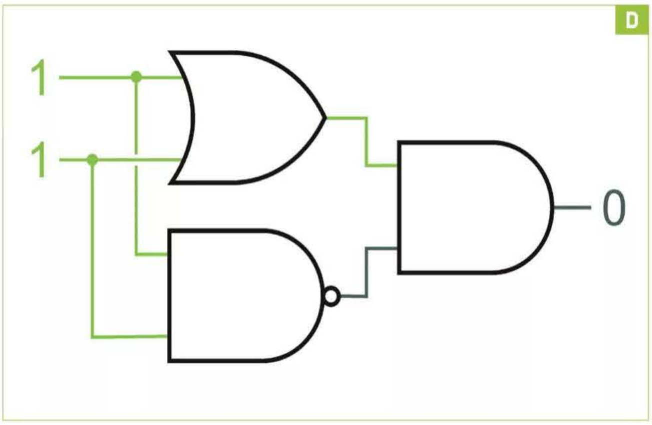


Input	Output
0	1
1	0

Inputs		Output
0	0	0
0	1	1
1	0	1
1	1	1

Inputs		Output
0	0	0
0	1	0
1	0	0
1	1	1



you use in these exercises. It's a useful exercise to sum up their working with a so-called truth table, which shows the output for each combination of inputs. These truth tables become much more informative with more complicated logic building blocks, but to illustrate the principle, we've provided the tables for the inverter, OR gate, and AND gate [**Image C**]. Finally, note that the symbol for the NAND gate is the same as for an AND gate with the addition of a circle on its output, and the same is true for the NOR and OR gates.

» Before moving on from gates, we really ought to take a look at the Exclusive OR and Exclusive NOR gate that we didn't see while experimenting with transistors. The Exclusive OR gate—often referred to as an XOR gate—produces a logic 1 if either, but not both, of its inputs is a 1. In other words, inputs of 0/0 and 1/1 give an output of 0, while inputs of 0/1 or 1/0 give an output of 1 [**Image D**]. This is our first example of how gates can be connected to create new logic functionality. From now on, we'll show just the circuit rather than a complete screenshot, even though we've confirmed them all in Logisim. Note that in our circuit diagrams, when lines meet or cross we use a solid blob to indicate that they connect, and in the case of crossing lines, we use a short break in one of them to indicate that they don't have an electrical connection between them.

7-SEGMENT LED

It might not be something that you'll need to understand how a microprocessor works—indeed, this would undoubtedly be something that would be done in software—but a good exercise to help consolidate what we've seen so far is to build a seven-segment LED decoder in Logisim.

Logisim has a seven-segment display as part of its library of components, but for this exercise it's too clever. What we mean by this is that it inputs a 4-bit signal and illuminates the appropriate segments to display the hexadecimal digit corresponding to the binary number on its inputs. In other words, it already includes the decoder that we're suggesting you design. Instead, use seven separate output pins or LEDs to represent the seven segments. To make it easier to see whether your circuit is working correctly, arrange them on screen so that they're in the same position, with respect to each other, that they'd be in a seven-segment LED.

Now you need to add four input pins, and between these and the seven positioned output pins, you need to devise and add some circuitry to drive those output pins correctly. There are several ways to do this, but in general the approach involves a layer of AND gates, the outputs of which connect to a layer of OR gates, and a few inverters. You should be able to do it with 16 gates, and four inverters.

3 DECODERS AND MULTIPLEXERS

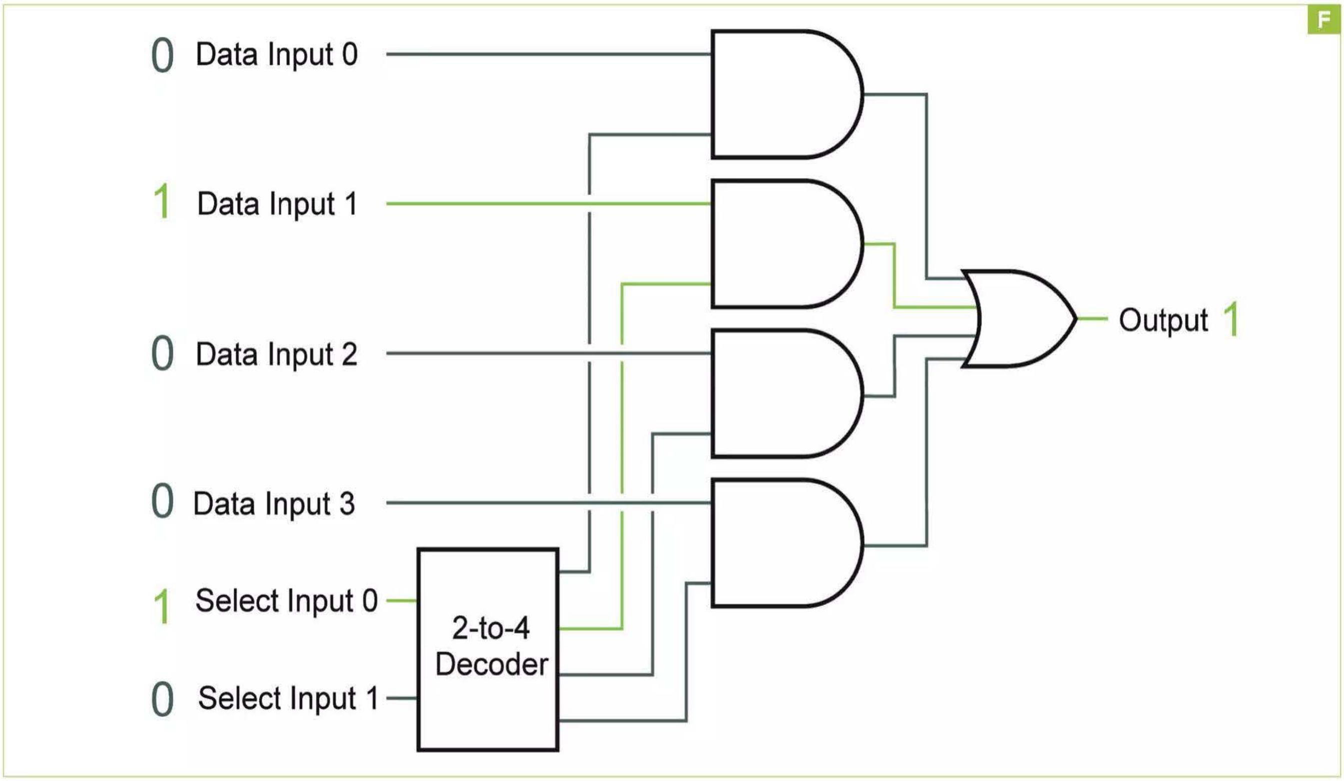
So far we've seen logic gates, but logical elements get more complicated than this, as we'll see with our next two building blocks: Decoders and multiplexers.

» A decoder takes a binary number as its input and produces a logic 1 on whichever of its outputs corresponds to the binary number. Decoders are more fully described by reference to the number of bits in the binary input and the number of possible outputs. Let's take the simplest—the 2-to-4 decoder—as an example, although common others include the 3-to-8 and the 4-to-16 decoders. The 2-to-4 decoder inputs a 2-bit binary number, and as a result, generates a logic 1 on just one of its four outputs, with all the others being logic 0. So, for example, if the inputs are 0 and 0—binary 00—a logic 1 appears at Output 0. Similarly, inputs of 0 and 1 generate a logic 1 at Output 1; inputs of 1 and 0 generate a logic 1 at Output 2; and inputs of 1 and 1 generate a logic 1 at Output 3. In addition to the inputs and outputs we've already seen, decoder circuits often have one or more enable inputs, which need to be at a specified logic level (1 for a positive enable input, 0 for an inverted enable input) for a logic 1 to appear at any of the outputs.

» The best way to get a feel for how a decoder works is to try it out in Logisim. Use the circuit diagram [**Image E**] for a 2-to-4 decoder with a positive enable input—or, if you just want to try out one without an enable input, just ignore the enable input and use 2-input AND gates in place of each of the four 3-input AND gates. If you want to try out a 3-to-8 decoder, or even a 4-to-16 decoder, it's not difficult to build on the principles used in the 2-to-4 decoder, but you'll obviously need to use more gates.

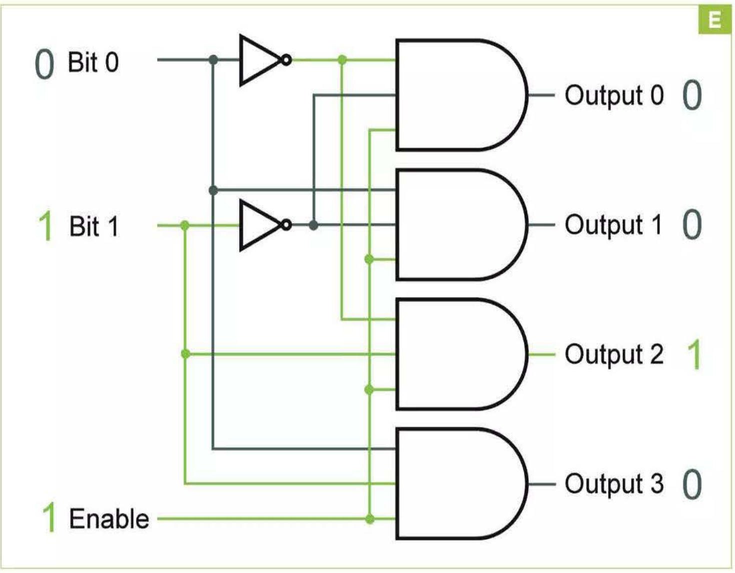
» If you're going to be saving your circuits for future reference, we suggest you label them to make them easier to understand in the future, rather like adding comments to code. You'll find that some components, but not all, have a Label attribute that enables you to define text that appears inside the symbol. Text can be placed at any position in the circuit: Select Text Mode by clicking on the A icon at the top left, click at any point in the circuit and type in your text.

» Having seen how a decoder is implemented using gates, let's turn to Logisim's built-in decoder, which we're soon going to use to create a yet more advanced logic building block. You'll find it under Plexers, and you'll notice that you can select the number of inputs, and also whether or not it has an enable input. Logisim


F

uses a trapezium as the symbol, but a rectangle is more common and is what we use in our circuit diagrams. The type we'll be using later is a 2-to-4 decoder without an enable, so choose 2 for Select Bits in the attribute table and "No" for Include Enable?.

» Perhaps unexpectedly, you'll see that the decoder only has one input instead of two; with the default attribute of East-facing, the inputs are at the bottom. That apparently single input is actually a bus, which is more than one signal combined into a single line to make the circuit diagram simpler and easier to read. This being the case, if you wire a default input pin to this bus, Logisim will complain about "incompatible widths." This means that although the bus contains the two signals that the decoder requires as its inputs, the input pin generates just a single signal. There are two possible ways to overcome this. One option is to select 2 as the number of Data Bits in the input pin's attribute table. The error message will then disappear and you'll notice that the pin now shows the values of two bits, both of which can be toggled. The alternative method is to use a component called a Splitter, which you'll find under "Wiring," and permits a bus to be split into separate signals—two, in this case. We'll leave you to figure it out, but this will enable you to connect two default, single-bit input pins to the decoder's inputs.


E

» With decoders in the bag, we can now turn to multiplexers. A multiplexer has several data inputs, one of which is switched through to its single output, depending on the binary value on its selected inputs. Let's think about a 4-input multiplexer to provide a more concrete example of how it works. In order to select one of the four data inputs as its output, this type of multiplexer will require two select inputs to represent a 2-bit binary number. If those data inputs are 0 and 0, this will cause it to switch data input 0 to its output. In the same way, select inputs of 0 and 1 will cause data input 1 to be switched to the output; select inputs of 1 and 0 will cause data input 2 to be switched to the output; and select inputs of 1 and 1 will cause data input 3 to be switched to its output.

» Now we're clear on what we want to achieve, it's time to put a circuit together in Logisim. The circuit we've provided for a 4-input multiplexer [**Image F**] uses a 2-to-4 decoder. While we could use the circuit that's made from individual gates, we're going to use Logisim's built-in decoder, because it'll keep things simpler and it's in keeping with the bottom-up design approach. So build the circuit shown in the circuit diagram and try it out; you should find that it implements the functionality described. The same principles apply to building an 8-input multiplexer, which requires a 3-to-8 decoder, or a 16-input multiplexer, which needs a 4-to-16 decoder.

» None of this might seem to take us anywhere closer to our goal of seeing how a microprocessor works. However, we're a lot closer than we were, because all these logic elements are essential components in a CPU—as we'll see in the next issue. In the meantime, play around with gates and see what you can make!

Pick The Perfect Parts For Your Next PC

YOU'LL NEED THIS

A WEB BROWSER
https://pcpartpicker.com

WE'VE ALL BEEN THERE, we've all sat down and thought to ourselves: "Huh, what parts should I pick for my next PC?" It's never an easy question to answer, and is undoubtedly why here at *Maximum PC* we get a lot of requests from readers, family, and friends on what we'd recommend they pick up for their next build.

As much as putting together a PC is akin to adult Lego, when it comes to picking the parts for that build, wading waist-deep through all those choices and deciding how exactly to allocate your budget isn't quite as simple. Especially for those who aren't as deep into the industry as we are.

So we're going to teach you the not-so-mystical ways on how we approach these questions, help you to get an understanding of how the value of the dollar changes depending on different factors, and how you can not only pick the perfect parts for your next rig, but also help out your friends and family who might have similar queries too. Let's dive in then shall we? –ZAK STOREY

1 THE BUDGET

Now this is the thing you're almost always going to want to nail down first. When it comes to your own rig, the budget is usually fairly obvious, but with requests from others, it can be a little less so. Often you'll find that you get two types of people when it comes to this: Either a) they give you a budget, but no guidelines as to what they need or want to do with the machine; or b) they'll just tell you what they want the PC to do, but give you no clue as to the price.

» Get that figure nailed down early. After all, there's no point spending an hour piecing together a part list and recommending a $2,500 rig to someone who has only got $700 to spend. Once you've nailed down the budget, you then need to realize that the value of the dollar changes depending on the size of the budget. For instance, at $400 it's far more important that each dollar is accounted for and allocated correctly than, say, at $3,000, where you have a bit more room for maneuver with performance parts.

2 THE AMBITION

This is intrinsically connected to the first point in many ways, and they often hold equal weighting. Now that you've got the price nailed down, you need to think about what exactly it is you want this PC to do. Specializing a rig allows you to pick parts that complement each other and make sense. Although almost all PCs are capable of doing any task you throw at them, allocating that cash correctly into key parts can make a world of difference.

» For instance, if your aim is to play games at 1080p, an RTX 3090 is going to be overkill, unless you're playing at super-high framerates, and even then you'll need one hell of a CPU. Or, if you're looking to start up a render farm or an always-on NAS, going with a traditional air cooler for your CPU makes far more sense than opting for an AIO cooler.

» You've also got to factor in the cost of your peripherals. If you want to game at 1440p, but currently don't have the screen, that's going to be an extra expense as well. And then there's the notion of being reasonable.

PICKING THE PARTS

But how do you pick the parts? Well, that is the big question—it's why *Maximum PC* exists today, to give you advice on this, and to provide you with reviews and expertise. However, if we're honest, you need to be looking everywhere for content. Google the part you're looking at, and check every website and publication for a review and benchmarks that are relevant to you. These are often big investments, so making sure you're not wasting money on a part that might be overkill for your situation is of paramount importance. So research, research, research.

Go to *PC Gamer*, to *Tom's Hardware*, to *Linus Tech Tips*, *Gamersnexus*, *HardwareCanucks*, *JayzTwoCents*, *OC3D*, *Kitguru*, and all of those other sites and look for their reviews on the hardware you're after. The more you know, the better off you'll be.

3 THE EXPECTATIONS

This mostly comes back to the budget, and it depends on the person you're dealing with. For many, if not all of you reading here now, you'll have a good understanding of what you can achieve for the money. For instance, $600 is probably just about enough to build you an ATX tower that can game comfortably at 1080p without a problem. However, 1440p and 4K isn't going to happen. Although we may be aware of this, for our friends and family who are somewhat less experienced with the ins and outs of the PC industry, that's less likely to be the case.

» Our best advice? Try your hardest, but let them down gently. Sometimes PC gaming can seem like a silver-bullet and super-affordable to many, but the reality is if they say they want a brand new 4K gaming PC for the same price as the latest PlayStation 5, it's just not going to happen. Here's some good examples of price ranges you can reasonably expect for certain aims. In fact, more often than not, this is what our various Blueprints are based off of.

- 1080p gaming = $600 - $1,400
- 1440p gaming = $1,000 - $2,000
- Ultrawide gaming = $1,200 - $2,400
- 4K Gaming = $1,400 - $3,200

4 SCURIOUS CONSIDERATIONS

So you've got your ambition and budget nailed down, what's next? Well, now you need to iron out the fine details and do a bit of research. Storage, memory, and cooling are perhaps the biggest considerations you're going to need to make straight off the bat. It's very easy to sink money into these without really needing to. And a lot of this is going to depend on how you use your PC. Memory usage is a prime example. Outside of specific scenarios, such as video-rendering and data-crunching (where more is always better), do you always have 50 tabs open on Google Chrome, do you have a ton of start-up apps, that stay on for long periods of time? If so, then 16GB perhaps isn't going to be enough for you. However if you're far more stringent in your browser usage and programs, 16GB could be more than acceptable. The same goes for storage. Do you have tons of media files you like to save locally? Or are you part of the streaming generation instead? How many games do you keep installed in your local library? Is your internet fast enough that downloading them again isn't a problem? Answering these kinds of questions can save you (or cost you) a lot of money.

» Then there's more questions to consider, like how much physical space do you have, and what are your ambient temperatures like? What case do you want to use?

4 BUDGET ALLOCATION

OK, so with all of that out of the way, let's say, as an example, we want to build a $1,500 1440p gaming PC, with the Hydra Mini case. Our end user uses a lot of tabs in Chrome, and additional programs. They want to have at least a 2TB SSD for their games and media, as well as a quick PCIe 4.0 drive for their OS, and they'd like it all to remain fairly chilled with an aftermarket air cooler as well for easy maintenance. So where to begin?

» Well, as a good rule of thumb, we typically break our rigs up into percentages like this to begin with.

- **CPU** 20 percent / $300
- **GPU** 33 percent / $500
- **Motherboard** 13 percent / $195
- **Remainder** 33 percent / $500

» You can move these sliders around ever so slightly depending on the weightings for each build scenario. We recommend that you always use PC Part Picker to initially plan out your build. So for instance, this is what we've initially specified. https://pcpartpicker.com/list/pC6Pb8. Now at the time of writing this list sits just shy of that $1,500 mark, but it doesn't account for the case (which we're adding on mentally, going from $1,460 indicated to $1,572).

» We've overshot our budget somewhat. Now we know that the primary aim is gaming, and we also know that the "must-haves" are the 32GB of DDR4 and the storage. As 1440p is more dependent on the GPU for gaming than the CPU, we can comfortably drop to a lower priced processor without losing any major performance. Going to a Ryzen 5 3600X means we'll still retain those high clock speeds, and have six cores for gaming, but it now brings us in at a total cost of $1,497. Right on target. However, it does mean that we're still going to be running that stock cooler.

» As motherboards don't really affect performance that dramatically, it's another area where we can cut back. As long as we retain memory compatibility, and have support for at least one M.2 PCIe 4.0 drive, then we're good to go. ASRock's B550M-ITX motherboard is currently $50 cheaper than the Gigabyte version, which gives us that to play with for a cooler as well, and you end up with something like this: https://pcpartpicker.com/list/Xp3j8M.

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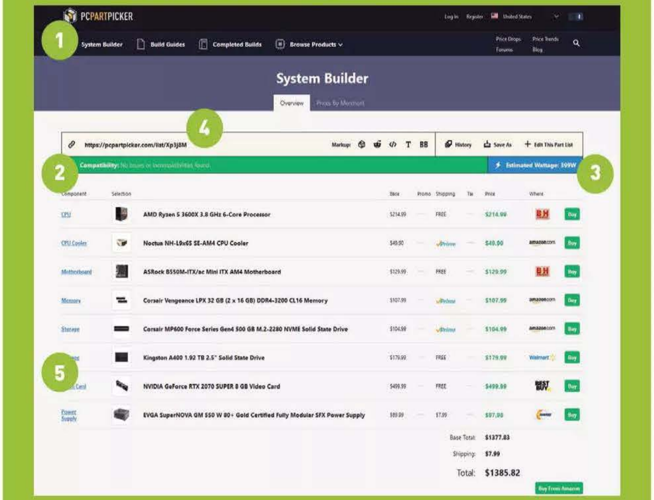
PC PART PICKER



System Builder

https://pcpartpicker.com/list/Xp3j8M

Compatibility: No issues or incompatibilities found.

Estimated Wattage: 399W

Component	Selection	Base	Promo	Shipping	Tax	Price	Where
CPU	AMD Ryzen 5 3600X 3.8 GHz 6-Core Processor	$214.99	—	FREE	—	$214.99	BH
CPU Cooler	Noctua NH-L9x65 SE-AM4 CPU Cooler	$49.90	—	Prime	—	$49.90	amazon.com
Motherboard	ASRock B550M-ITX/ac Mini ITX AM4 Motherboard	$129.99	—	FREE	—	$129.99	BH
Memory	Corsair Vengeance LPX 32 GB (2 x 16 GB) DDR4-3200 CL16 Memory	$107.99	—	Prime	—	$107.99	amazon.com
Storage	Corsair MP600 Force Series Gen4 500 GB M.2-2280 NVME Solid State Drive	$104.99	—	Prime	—	$104.99	amazon.com
age	Kingston A400 1.92 TB 2.5" Solid State Drive	$179.99	—	FREE	—	$179.99	Walmart
Card	NVIDIA GeForce RTX 2070 SUPER 8 GB Video Card	$499.99	—	FREE	—	$499.99	BEST BUY
Power Supply	EVGA SuperNOVA GM 550 W 80+ Gold Certified Fully Modular SFX Power Supply	$89.99	—	$7.99	—	$97.98	

Base Total: $1377.83
Shipping: $7.99
Total: $1385.82

1. https://pcpartpicker.com is our go-to site for deciding on what to put in each build. It's a good database, but not perfect—some parts won't be listed here.

2. If you choose the wrong parts, or components with incompatibilities, it'll highlight them up here. From missing coolers to incompatible processors.

3. The wattage calculator here gives you an estimate of max power draw under load. Ideally you're looking for that figure to be 80 percent of your PSU's maximum rating, or 70 percent if you plan on overclocking.

4. You can share your proposed build with family and friends by copying the link here, which is handy for suggesting builds. They don't necessarily need to buy through the site, but it can give them a good idea as to what they should look for.

5. Each category has a myriad of filters you can apply. For instance, when looking for memory, we set our capacity, then specify a frequency range before sorting by price to find a decent deal.

5 THE BUDGET NUDGE

Now, that's not the perfect build for the price. The perfect build is $1,522 and swaps out the Noctua NH-L9x65 SE-AM4 for a be quiet! Dark Rock Pro instead, which keeps the entire rig looking cleaner and cooler in the process. It's not a huge performance gain, but it does look better for an aesthetic build like the Hydra Mini.

» This happens a lot, and often in a more impactful way than just swapping out a cooler. Sometimes you can be $20 away from a better graphics card, or a CPU upgrade, or even an SSD change. Or perhaps something new is about to launch that blows the rest out of the water. In those scenarios it's often better to either nudge the budget slightly upwards, or be patient and wait a month or two for the new parts to filter in, or until you've got that little bit more extra cash to be able to afford the slightly better component.

» It's important to remember however, given the nature of how fast our industry advances, you can be waiting forever, so it is sometimes best to pull the trigger now, and invest so you've got that rig ready to go. ⏻

DIY Custom Sleeving Part 1

YOU'LL NEED THIS

TOOLS

Sleeving, wire, heatshrink, patience, and tough fingers.

CABLES IN PCS ARE OFTEN AN UNRULY MESS. We're not just talking about bad cable management either—the physical look of them can ruin the prettiest PC. Thankfully, it isn't often that we see the old-style "ketchup and mustard" cables anymore, and nowadays higher end PSU manufacturers are even doing pre-sleeved cables with their products, but still they're often the incorrect color or just look wrong. You are also at the manufacturers' mercy as to how long they are. Today we'll show you what you will need to tame these snake-like beasts and get those PCs looking as good as you do. We will do this in multiple parts, as cable sleeving takes some explaining, and it does have an element of risk. This first part of the tutorial will go through the tools that you will need and also a brief rundown of the types of sleeving. In the next issue we will start getting down to some actual sleeving and then into some of the advanced methods, such as spliced Y cables.

Once you factor in the price of the tools, the cost of the materials, and the time spent on sleeving your own cables, you'll begin to realize it isn't exactly cheap to do. However, if you do go for it, you get a real sense of satisfaction, and you can sleeve to your exact specifications—that means tight, clean, tidy cables, in the perfect color, at the perfect length, with no excess kicking around that you have to hide away under some power supply cover or under the back panel. This is why custom hand-sleeved cables will always have a place in the modding scene. But what exactly do you need to get started? Well, let's take a look. –DAVE ALCOCK

1 TOOL KITS

You will need some tools for this venture, and we're going to run through the ones we use the most. We have tried many tools and sleeved hundreds of cables, and getting the right tools for the job is very important. Having said that, it also doesn't make sense economically to purchase the very best of everything if you are only going to sleeve or make a single set. If you are only doing one set of cables, or a couple of sets, the Alphacool Eistools crimping kit is a great option. At approximately $50 with everything bar a lighter included, it is hard to beat in terms of value. However, there are much better options overall if you are looking to do multiple sets or want to spend the extra cash. At a mid to high level, the MDPC tools from www.cable-sleeving.com are fantastic, and this is what we generally use. [Image A]

2 CORD TYPES

Before we go through the tools, let's talk about the two most common types of sleeving: PET (orange) and paracord (gold). PET is made of multiple strands of plastic interwoven to make a sleeve. The quality can vary quite a lot, with MDPC-X and Teleios sleeving being in the higher tier. PET sleeving is normally shiny, expandable, and able to keep dust/dirt at bay easier than paracord. The negative side of PET is that, due to how it expands, you might get cable bleed, where you can see the wire through the sleeving. Tensioning the sleeve correctly should stop this, but you will also want to choose your wire color carefully. If you're making fully custom cables, as we are going to be doing, use white wire for light-colored sleeves, and black wire for dark sleeves.

»The second option is paracord. This is a soft nylon material and has no cable bleed due to the tight weave. Paracord is cheap and cheerful and can look great. However, it can also get very dirty as it is more like a cloth, it can snag, and it can look like it has lumps and bumps depending on how the wire sits inside it. We usually opt to use PET when we're doing our own custom cables. [Image B]

ANOTHER CUSTOM SLEEVING TUTORIAL NEXT MONTH

3 CUTTING AND STRIPPING TOOLS

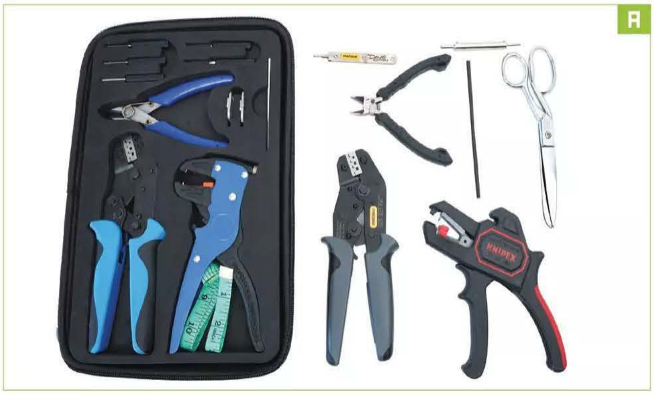
You will need to cut the wire, strip the protective insulation from it, and you will also need to cut the sleeving. There are some tools that can do all of these jobs, such as the very nice Knipex stripper—although fantastic for stripping, it's less ideal for cutting the wire or sleeving. To cut the wire, we use a good set of side cutters, and to cut the sleeving we either use the wire cutters or, even better, a pair of scissors. [Image C]

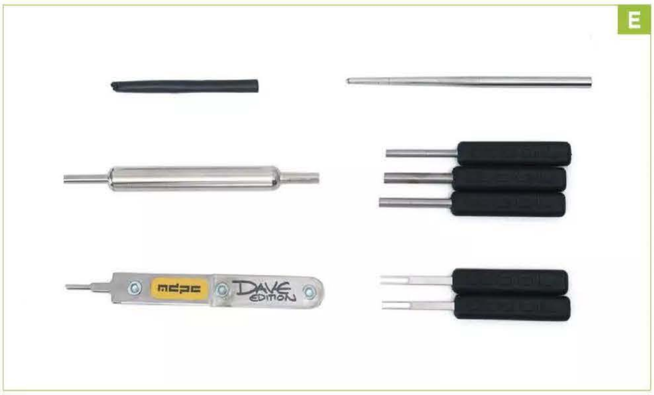
4 CRIMPING TOOL

Crimping tools are the most important tools to get right, and there are many duds on the market. Crimping tools crush the terminal onto the stripped wire and allow the wire to be pushed into the connector. The MDPC CTX3 tool is a great option, and if you are only using it for sleeving it will likely last you a lifetime. The only thing better than this would be the professional range, which are 10 times the price. If the CTX3 is too expensive, the one included in the Eistools kit is also good for the price. It does take a little more practice to get the "perfect crimp." The terminals simply go into the jaws of the tool, and you squeeze the handles together to compress it. [Image D]

5 DEPINNING TOOLS

Depinning tools are designed to remove the pins from power connectors and stock cables. As long as the prongs are able to hit the flags of the terminal and compress them, they will work. Our favorite ATX/EPS terminal depinning tool is the snappily named Molex 11030044. It's easy to hold in your hand, is long enough to stay comfortable, stronger than most, and it just works. The cheaper ones do work, but you are much more likely to snap them. The Molex ones can snap too—this is probably the most tricky part of cable sleeving,





especially if you are sleeving original cables rather than making your own. To remove 4-pin Molex terminals, you use the circular tools. These are usually very cheap.

»The last tool that is useful here is a sleeving needle. The one in the Alphacool kit is a nice metal tool that helps you to push the terminal and wire through paracord without it getting snagged on the soft material. As an alternative, the thin cocktail straws that are found in bars are great too; in fact, we often prefer them, as the prongs on the terminal can snag into the plastic of the straw, and grips the terminal rather than the metal one where it can slide out. To use the straw method, you will need to melt the end of the straw and mould it into a soft point. [Image E]

6

LIGHTERS

The last item we're going to mention is the lighter. If you're using PET, you'll need this to melt the heatshrink and sleeving, and with paracord you'll need it to melt the sleeve only, as you usually won't need heatshrink with paracord. When selecting your lighter, stay away from Zippo-style ones. These leave a lot of carbon on the sleeve and don't seem to work well. The same goes for a candle. Our preference is either the Bic or Clipper-style lighters, but we often just go for very cheap ones, as you can buy 50 and keep some in every tool box. [Image F]

» That is basically everything you will need to start. Of course you will need sleeving materials as well, and for the more advanced methods you will likely need a soldering iron, but with the tools outlined above, you can certainly do the majority of the jobs. We look forward to getting into the nitty-gritty in the next issue to show you how to break into this art form.

PRE-BRAIDED CABLES

If cable sleeving is too tedious or overwhelming for you, there are many companies that make pre-sleeved cables. CableMod is the most popular. These are somewhat custom as you can choose your color, cable length, cable comb, and connector direction, but you are still limited between these variables. If you just want quick, colorful options, though, it could be the cheapest way to get either extensions or complete replacement sets. Some manufacturers also have their own braided cables, so it could be worth looking at their websites to check if they have what you desire.

BUILD IT

ZAK STOREY, EDITOR

Mystical Monster

This issue, Nvidia's new Ampere architecture meets overkill RGB

LENGTH OF TIME: **1-2 HOURS** | LEVEL OF DIFFICULTY: **EASY**

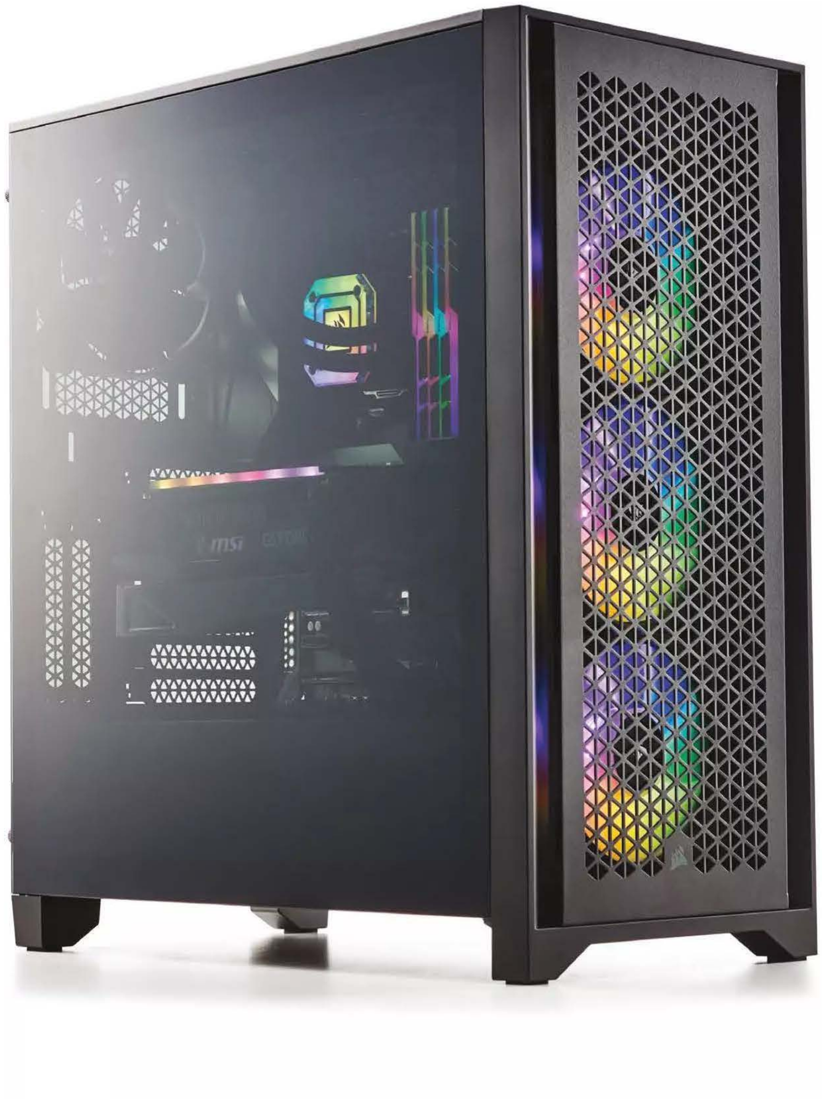
THE CONCEPT

COME ON NOW, you knew it was coming. You can't launch a major new GPU architecture and a swathe of graphics cards and expect us here at *Maximum PC* to not go out and put together a ridiculously over-the-top, super-powerful, super-expensive machine. It's in our nature. So that is exactly what we're doing here today.

However, if I'm honest, it being this colorful is a happy accident—depending on your point of view anyway. It's certainly not something we set out to achieve, but it's part and parcel of working with the brands we do—more on that later.

So what's the ambition? Well simply put, to see how well MSI's GeForce RTX 3080 Gaming X Trio can perform in an actual PCIe 4.0 rig, with a fairly solid base spec. We've got a full in-depth deep dive into Ampere's architecture on page 38, and a review of the Founder's Edition card on page 68, but this is our first look at an aftermarket card, and that raises a lot of questions. There's been some furore surrounding capacitors on these cards, especially the aftermarket variants, as they seem to be running at the absolute limit (built to Nvidia's specs), and any attempt to overclock leads to blue screens and crashes. Secondly, these things are seriously big, and as the cards are known to draw more power than ever before, I want to take a look at a) just how noisy they are, and b) whether the temps are actually that bad.

That's actually one of the big advantages of being a tech journalist in print: We don't have to rush our work to be the first out. We can take our time, find any bugs, and report on them too, giving you all the best information. Let's dive in!



PART SELECTION

SO THEN, on to the parts list. What have I got for this rig? Well first up is the processor, and at its core I'm running an AMD Ryzen 7 3800X. This is one of the more top-end processors from AMD for this current generation. It's got eight cores, 16 threads, and a beefy 4.5GHz turbo clock speed at max. Single-core performance is solid, and it's got plenty of headroom in games too. Combine that with PCIe 4.0 support and a bevy of additional features to get the most out of it at stock, and it's a good pick for this test system.

Moving on to memory, and I'll be pairing this with 32GB of G.Skill's Trident Z NEO memory at 3600 MT/s, which is sort of the sweet spot for 3rd-gen Ryzen. I'll be slotting all of that together inside one of Corsair's latest 4000D Airflow chassis, and then I'll complete the look with a Corsair iCUE H150i Elite Capellix AIO liquid cooler too.

And as for the wild cards? Those are reserved for the storage and power supply. I've gone with the Samsung 970 Evo Plus 1TB, just for testing purposes, and one of be quiet!'s latest Dark Power Pro 12 1200W 80+ Platinum PSUs. The latter was actually a stand in; I was intending to use one of Corsair's latest CX750F RGB power supplies as well, just to really go for RGB overkill, but sadly it arrived a day after our photoshoot, due to that pesky coronavirus delaying shipments from Taiwan. That said, the Dark Power Pro series has long been a workhorse of ours, and this one will go on to become our permanent test-bed PSU as well, at least once we're allowed back in an office again.

INGREDIENTS

PART		STREET PRICE
Case	Corsair 4000D Airflow ATX Mid Tower Case Black	$80
Motherboard	Asus ROG Crosshair VIII Hero	$380
CPU	AMD Ryzen 7 3800X	$340
GPU	MSI GeForce RTX 3080 Gaming X Trio	$760
Memory	32GB (4x8GB) G.Skill Trident Z Neo DDR4 3600 CL16	$175
PSU	1200W be quiet! Dark Power Pro 12 80+ Titanium	$400
Storage	1TB Samsung 970 Evo Plus	$170
CPU Cooler	Corsair iCUE H150i Elite Capellix	$190
OS	Windows 10 Home 64-bit OEM	$24
Total		$2,519

1

TRIPTYCHAL BRILLIANCE

APPARENTLY THIS STYLE of image is called a triptych, according to our photographer. I just asked for three side-by-side shots comped together, but hey, you learn something new every day. I want to highlight these three areas specifically to give some understanding as to what makes the 4000D Airflow such an impressive case, and it's all about that attention to detail.

This is an $80 chassis, and it's not a lot for what you're getting, really. The yellow thumbscrews, the subtle branding and tabs, the new design language, and yet with an attention to performance detail that just has to be admired, all make this one of my favorite cases of 2020. It's a big reason why I've picked it not only for this build, but also for our Blueprint budget case going forward (next issue)!

2

NOT WITHOUT FLAWS

THAT SAID, THERE'S A REASON we don't give out 10s at *Maximum PC*, and that is because nothing is flawless. There's always something, and here we have another example of that. During my usual chassis stripdown (basically remove everything that's not needed from the case and call it a day), I noticed that this hard drive caddy has retainable Phillips-head thumbscrews located inside the case itself. Now that's fine, but they're factory tightened to an unbelievable degree, and it's darn hard to get a screwdriver in there to undo them. I ended up using a small set of grips just to loosen them off enough to get my fingers in there and get the caddy out.

Why not just leave the caddy in? Well, the Dark Power Pro 12 is a beast of a PSU. In fact I've never seen anything quite so large, especially in a chassis of this size.

3

MOBO MANSLAUGHTER

SERIOUSLY, HOW EXPENSIVE are motherboards getting these days? This once "mid-range" Hero board from Asus is $380! That's more than the cost of the eight-core, 16-thread processor at its heart. Just crazy. But one thing I can say is that this thing looks stellar, and has some serious connectivity to boot, including multiple PCIe 4.0 slots, a sizable VRM cooling solution, and more rear I/O than you can shake a cat at (that's just a saying...).

I'm pre-installling the CPU here before placing the board in the chassis, and also making sure that the stock back-plate is still required for Corsair's fancy new AIO Capellix coolers.

4

INTAKE ANNOYANCES

FOR OUR AIO INSTALLATION, given the impressive-looking airflow in the front of the 4000D, I've decided to place the 360mm rad in the front of the chassis, drawing cool air in via those three static pressure-optimized RGB fans. Now this does mean that we'll see slightly higher GPU temps, as the air will be getting heated via the radiator as it passes through, but on the whole that should only be around 2-3C higher than if we were using this as an exhaust instead in the roof.

One thing to note is it is an utter nightmare to install the three fans to the radiator and the front of the chassis. Take your time, use two screws per fan at first, and don't tighten them all the way until all three fans are in position and are secured to the radiator. You'll need as much wiggle room as possible.

7

RAMMING SPEED!

TO RAMP UP the RGB goodness I've gone for a kit of G.Skill's Trident Z Neo memory—32GB of it. Complete with a 3600MHz frequency and a C16 latency, it's been optimized for Ryzen processors. It doesn't amount to a whole lot in terms of performance in the real world, but it does mean I should end up with less motherboard incompatibility and instability.

There's been a lot of different variants of G.Skill's Trident Z RGB memory, and although not quite as bright as the Capellix LEDs used in the likes of Corsair's Dominator Platinums, these are some of the brightest we've seen, and it's hard to argue with the styling either.

8

GOLIATH SUPPLY

THIS PSU CHOICE was a bit of a last-minute decision. I was expecting Corsair to deliver one of its latest CX RGB power supplies. The fans in these latest PSUs feature RGB lighting, so you can face it up into the chassis to add a bit of extra illumination through the PSU cover, or face it downwards to get a sort of soft underglow at the back of the rig. They're fairly inexpensive too, although they come with an 80+ Bronze rating and tap out at 750W.

Unfortunately it didn't arrive until the day after our shoot, and so I had to opt for a significantly pricier alternative we had in our storeroom.

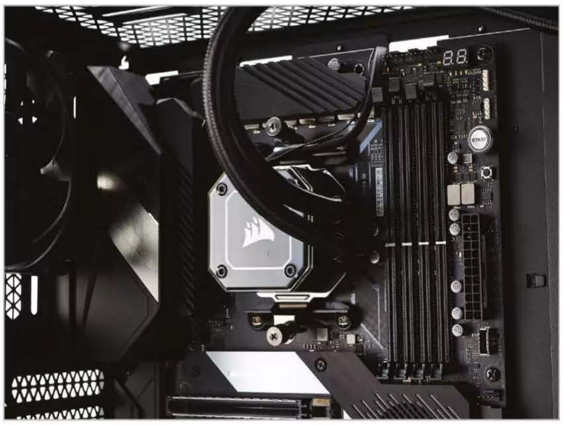
So here we have the latest Dark Power Pro 12 from be quiet! It's seriously big. Even the box itself is insane. I've popped in a 120mm fan here for scale, but it's just utterly massive. There are no gimmicks or RGB lighting, just hyper-quiet, monstrous power-supplying goodness to enjoy.

DARK POWER
1200W

5 COOLER MOUNTING

ANYONE WHO'S FAMILIAR with Corsair's AIO mounting design for AMD chips will recognize the mounting mechanism here. Attach the correct AM4 mounting bracket to the CPU block, then carefully pre-install the two thumbscrews/nuts and hook screws on the other side. Then hook the CPU block over the two notches on the stock bracket, and carefully tighten. Remember to remove the plastic label from the CPU block base, and add a small blob of thermal paste too.

It's then a case of running the CPU pump and RGB cables up and out of the way round the back of the case, plugging them in to the RGB fan controller that comes with the cooler, and one to a fan header on the board.



6 STORAGE CONFUSION?

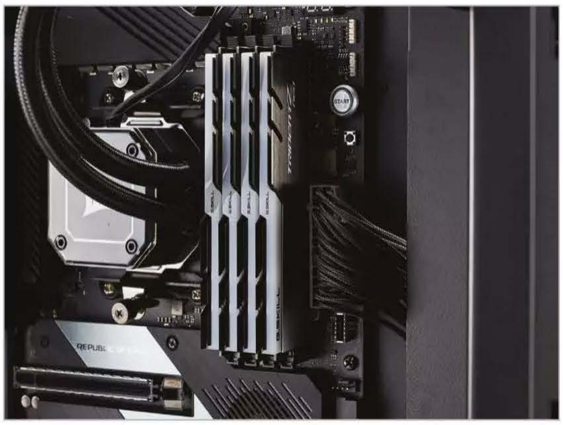
WHY SO LITTLE STORAGE? Well simply put, this is all due to this thing being set up as a test-bed first and foremost. Although it's a good platform for a build, I'm only including a single 1TB Samsung 970 Evo Plus for our OS and testing games.

The long-term intention is to swap out the processors and see at what point in the Ryzen product stack the processor becomes the bottleneck at 1080 and potentially even 1440p.

9 CABLES FIRST?

I DECIDED TO do something different with this build and to actually install and route the majority of the cables first, before installing the power supply. Typically what we recommend is that you identify the cables you need, plug them into the modular supply, then slot that in the chassis.

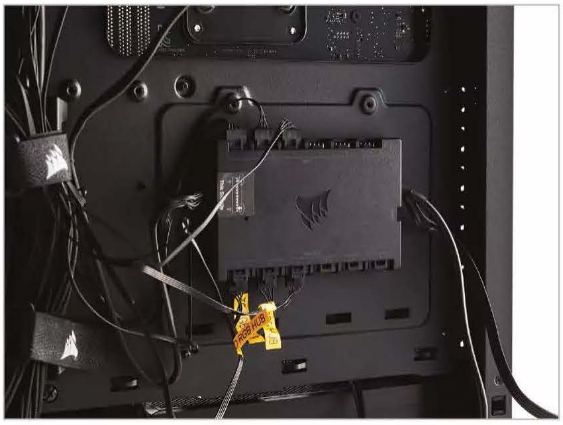
Given the size of the DPP12, and mostly because I wanted to see if this was easier, I've opted to try it this way instead. Turns out it's a bit more of a pain in the butt, and I should've stuck with option one. You also can't install all the cables, as the graphics card isn't in either, and there's various I/O stuff that requires power too. So here I've installed the 24-pin, the CPU power, and then moved on to all the front I/O cables as well.



10 BLESSINGS AND BINDS

WITH EVERYTHING IN POSITION, it's time to install the included RGB and fan controller bundled with the cooler. Annoyingly the fans' RGB cables have a proprietary connector that plumb straight into this little controller box here. You then power that via a SATA power, and connect it to the motherboard via USB 2.0 cables. Fortunately the fan header itself is still of the PWM variety.

This could be a blessing or a curse, depending on your preference. I've removed the two SSD caddies from the back of the 4000D here, and then attached the Corsair controller with two adhesive strips included with the cooler. It's neat, gets the job done, but is a bit annoying for cable management.

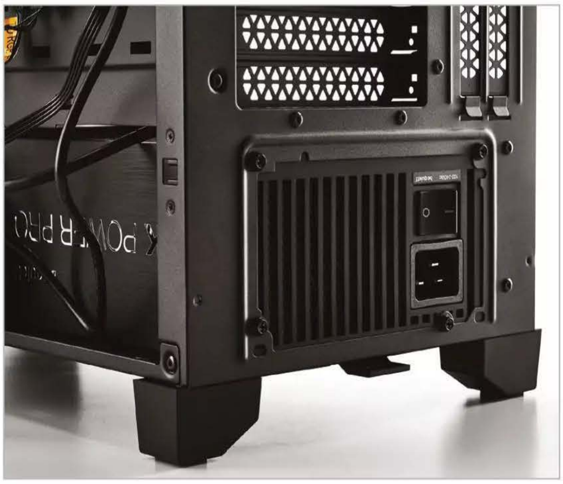


11

GOING BEYOND THE LIMIT

THIS IS SOMETHING RARELY SEEN on power supplies under the 1000W marker, but on the more premium solutions can be a common sight. It isn't your standard kettle lead that's needed for this, but instead a C19 lead. Unlike the standard kettle lead, these can handle up to 16A of current (as opposed to 10A), and are more often found in industrial applications than in the world of the common PC.

Be quiet! includes a cable as standard with the PSU, but be warned: The cables are significantly thicker and better insulated than their more common counterparts.

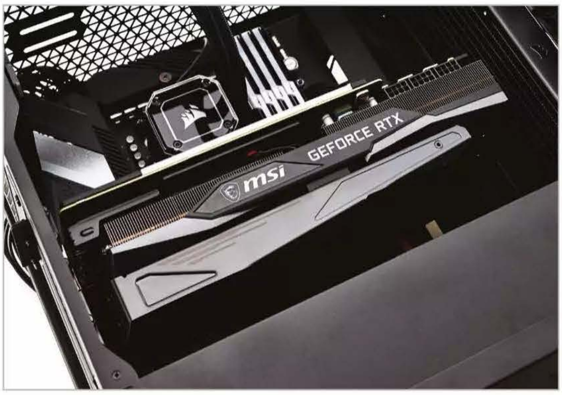


12

MONSTROUS ANOMALIES

THERE'S NO OTHER WAY of saying it: This card is huge. It is an absolute juggernaut of a graphics card. The cooler is easily a three-slot, and on top of that it comes with a huge support bracket that needs placing underneath, taking up a grand total of six PCIe slots in the case itself.

It's a good job that Nvidia doesn't support SLI anymore, because you're not going to have much space for a second card. On top of that, check out all those PCIe power connectors! It's worth noting that this is just the standard Trio Gaming X card, not some hyped-up super EVGA Black Edition, or something crazy like that. On the plus side, it doesn't have one of those funky power connectors seen on the middle of the Founder's Edition cards, so it's far cleaner.



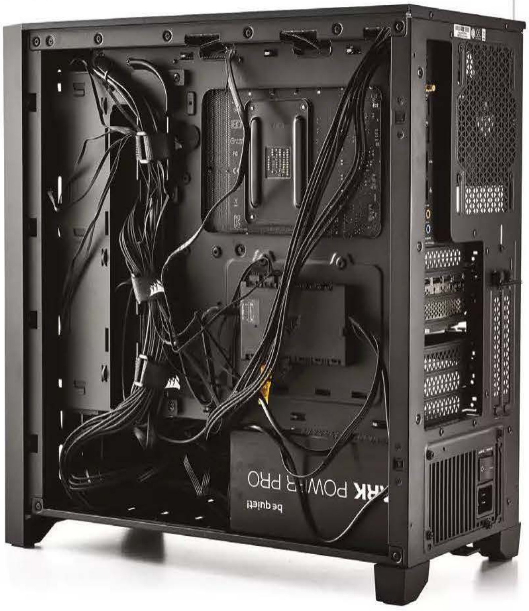
13

ALMOST FINISHED?

AND THERE YOU HAVE IT, I'm almost completely wrapped up with the build here. There's just a teeny, tiny bit of cable management to not really wrap up in the rear, and we'll be good to go. So a few things to note.

I utterly adore those little Velcro cable straps included with the 4000D Airflow; they actually have a plastic bracket attached to them to thread the Velcro through, which helps, and each one is of course braided with that Corsair logo too. You also get a few more of these in the case accessories box.

And the eagle-eyed among you will probably have spotted the cable-tidy bar that's running down there as well, which is not too dissimilar from those that can be found in the original NZXT cases. That's pretty neat, huh?

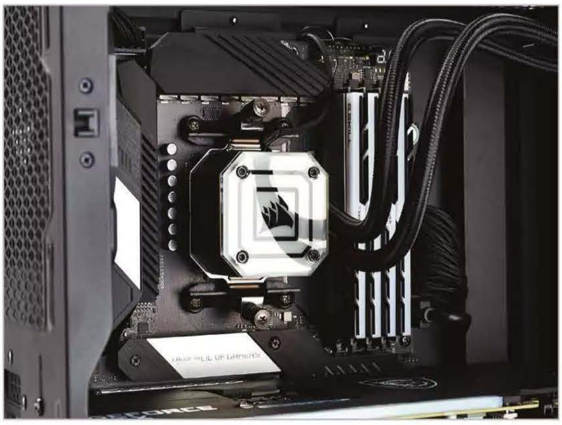


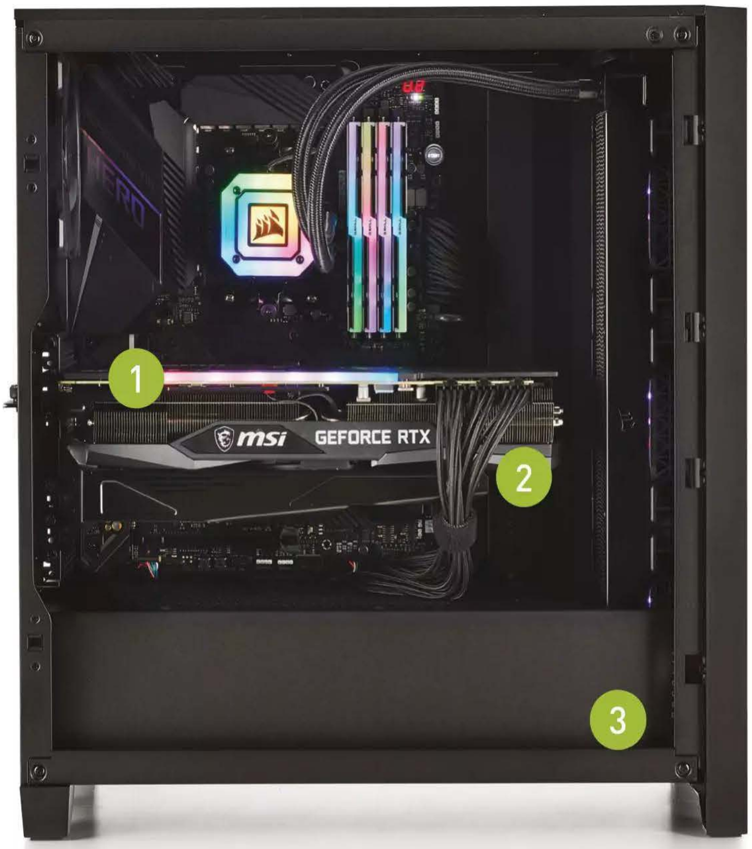
14

DESIGN SWAPS?

BUT WHAT IF YOU'RE FED UP with that CPU block design? Well you can swap it out for something different. The plate on top is secured via four Allen-key screws. Simply unscrew them, and you can swap them out for this clear bracket, or your own design. The white you're seeing isn't on the plexi bracket itself, but is actually the frosted acrylic sitting on top of the Capellix LEDs underneath to help diffuse the light.

Any downsides? Well Corsair includes a ridiculous plastic Allen key to undo them, and it's awful. Apparently this is to ensure that you don't damage the threads on the screws, or over-tighten them, but our sample didn't work, so I threw it out and opted for a metal one instead.





① We sort of understand what MSI is trying to do with this light bar on the graphics card, but as you can see from G.Skill and Corsair above, light diffusing clearly isn't the design team's biggest strength.

② You can theoretically install a PCI device underneath this GPU support bracket, but a word of warning: It's a pain in the butt to install to begin with.

③ You can just about see it here, but Corsair's got a lot of subtle branding all over the 4000D Airflow, from the model name on the right of the PSU cover to the new font and yellow square lining the rear-most cable cover bar.

CONCLUDING THOUGHTS

ALL IN ALL THE BUILD process for this rig was fairly smooth. It's funny: Year after year I've been building systems, and I'm not sure if it's a combination of more experience and a particular procedure I follow, or whether it's chassis design getting better, but it is so easy now to build your own rig. I can't stress that enough. If you've spent any time reading *Maximum PC*, and you're still worried about building your own rig, or don't want to stress yourself with the time it takes, believe me, you've got nothing to worry about, you're more than capable. I'm positive pretty much anyone can build a system, and in not a lot of time too—unless you're dabbling at the more extreme ends, such as with liquid cooling.

Even looking at this build it's hard to think of anything that could easily go wrong. There's some housekeeping stuff perhaps. You could wear woolly socks and build it on a fresh carpet, or accidentally knock off a capacitor (which requires a lot of effort), or use conductive thermal paste and spill it all over the socket (although there's very little of that conductive stuff left out there at this point). But aside from that, if you've spent time reading a guide or examining the process of building a PC, it's hard to go wrong. Everything's notched a certain way, or designed to minimize the chance of breaking things. In fact, I reckon the only thing still left that poses any sort of danger is Intel's LGA socket, or AMD's processor pins, and even then you're dealing with that situation for all of about two minutes, if that.

All that aside, how does it perform? The RTX 3000 series is a game-changer for gaming at 4K. Here we're comparing it against the Hydra Mini from a few issues back. The difference between the two extends to $200, which mostly falls on the processor, motherboard, and power supply. Additionally the Hydra Mini features an Intel Core i5 processor, while this one houses the AMD Ryzen 7 3800X, which is somewhat slower for gaming. With similar original price points, the two cards make for a good comparison.

What are we seeing? Well, average framerates in *Shadow of War* were 81fps, *Total War* was 94fps, and *Assassin's Creed* was 59fps. That difference is huge, near 80 percent increases in most cases: Not the 100 percent increase with the 3D Mark result, but still an incredible performance boost.

On the whole it's not too noisy, and the crashing bugs that occurred at launch seem to have been fixed with the latest driver update. Is this all the card you'll ever need then? It certainly looks that way. I'm just sad I have to give the card back to MSI.

We're approaching the point where GPU performance outweighs monitor tech, and unless higher spec monitors come down in price, the need for flagship products like the RTX 3090 is difficult to justify.

BENCHMARKS

	ZERO-POINT	
Cinebench R15 Multi (Index)	1,350	2,221 (65%)
CrystalDisk QD32 Sequential Read (MB/s)	3,536	3,542 (0%)
CrystalDisk QD32 Sequential Write (MB/s)	3,196	3,154 (0%)
Middle Earth: Shadow of War (fps)	55	81 (47%)
Total War: Warhammer II (fps)	47	84 (78%)
Assassins Creed Odyssey (fps)	36	59 (64%)
3DMark: Fire Strike (Index)	22,306	42,255 (89%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our zero point consists of an Intel Core i5-10600K, 16GB of DDR4 @ 3600, a Zotac GeForce RTX 2080 Super AMP Extreme, and a 2TB Samsung 970 Evo Plus M.2 PCIe 3.0 SSD. All tests were performed at 4K with the highest graphical profile.

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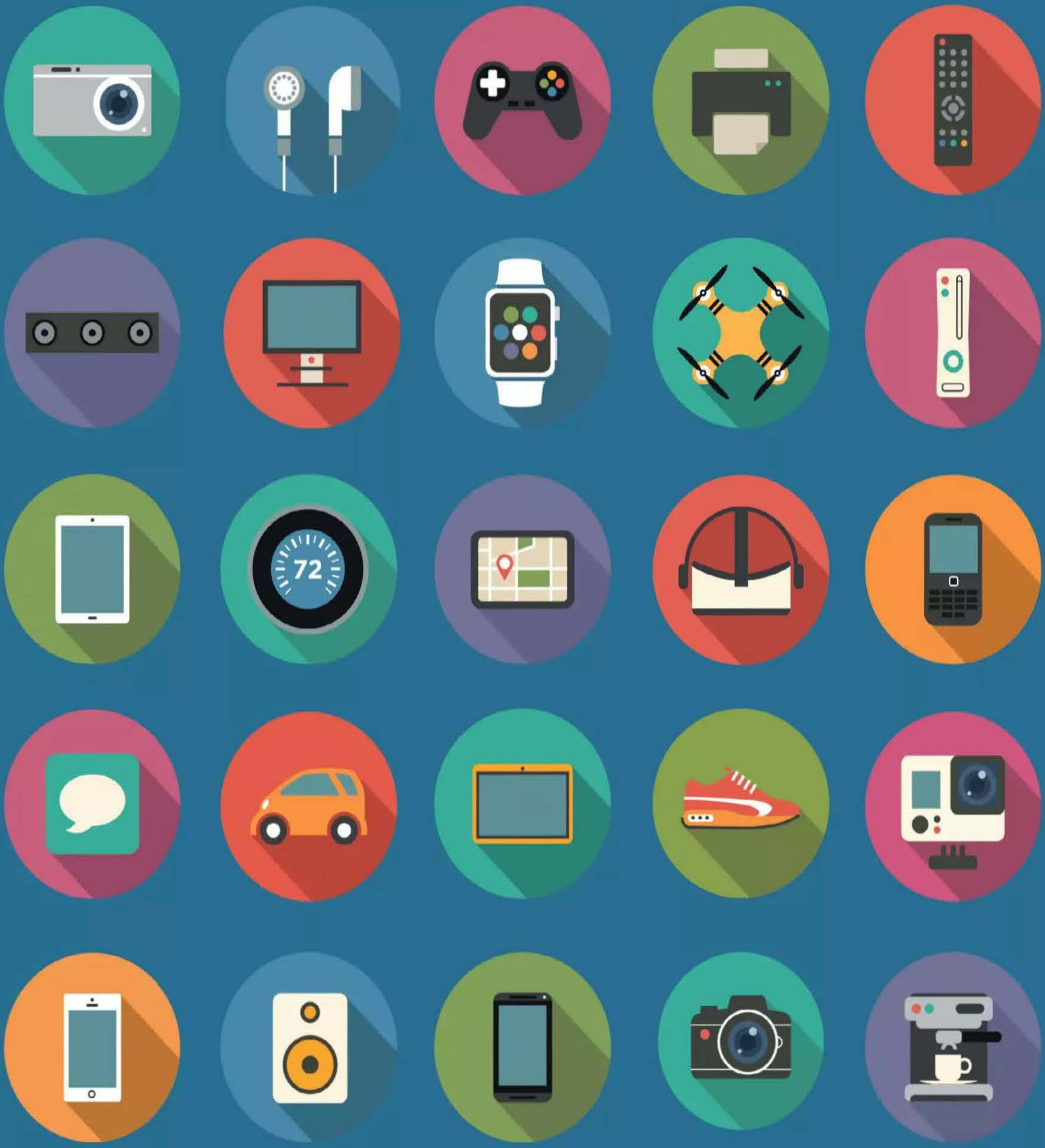

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ASUS MAXIMUS EXTREME PAGE 70

Nvidia GeForce RTX 3080

Time to get Ampered for Nvidia's new starting lineup

THE GEFORCE RTX 3080 finally kicks off the new season of GPUs, sporting Nvidia's new Ampere architecture (see: Ampere deep-dive, page 38). Forget the star players of the past couple of years; the hot young talent is ready to kick some serious ass. Even better: Nvidia isn't asking for a massive signing bonus this round. The RTX 3080 takes over the outgoing RTX 2080 Super's $699 price point, which means gaming enthusiasts can actually afford one (almost).

Just about everything has changed with the 3080 Founders Edition. It looks nothing like previous Nvidia GPUs, and frankly looks nothing like any other GPU we've seen. It has dual fans, but in a novel approach to cooling, the axial fan that's closer to the video ports serves as something of a blower, while the back fan sits on the opposite side of the card and pulls air through the radiator fins. Nvidia claims it provides better cooling and lower noise levels than the previous generation, and our testing backs that up.

Load temperatures on the 3080 FE peak at around 70C, but fan speeds hover around 1500rpm, resulting in 50dB noise levels at 15cm. The 2080 Super, in comparison, runs at similar temperatures, with 1700-1800rpms on the fans and 52dB noise levels. Oh, and the RTX 3080 FE pulls 333W compared to the 2080 Super's 246W. That's 35 percent more power and heat to dissipate, and it stays quieter while doing so.

New to the Ampere GPUs is HDMI 2.1 support, which allows for up to 8K60 viewing using a single cable, provided you use DSC (Display Stream Compression). Native 8K gaming is still going to be a stretch for the RTX 3080, but Nvidia updated DLSS to version 2.1, with a 9x scaling factor that will use deep learning to intelligently upscale and anti-alias 1440p content to 8K. The DisplayPort 1.4a ports also support 8K60 via DSC. If you have an 8K TV, the 3080 is your best option for 8K gaming right now, though the far more expensive RTX 3090 more than doubles VRAM capacity and is perhaps a better fit if you're serious about 8K.

POWER PLAY

With all the changes and improvements, gaming performance ends up being a massive generational leap. The RTX 3080 outperforms even the Titan RTX by over 25 percent at 4K ultra. It's also 31 percent faster than the RTX 2080 Ti, 58 percent faster than the RTX 2080 Super, and 70 percent faster than the RTX 2080. Drop down to 1440p ultra and the margin of victory shrinks to just 55 percent versus the 2080, and at 1080p ultra it's only 42 percent faster. This is very much a card designed for 4K ultra gaming, then, though it sweeps every benchmark at 1440p and even 1080p as well.

If you're running some of the latest games that support ray tracing and DLSS, the gap can be even larger. In our Control, Bright Memory Infinite, and Boundary testing, the 3080 was up to twice as fast as the previous-generation 2080. These tests may be a better indication of where gaming is headed, considering next-gen consoles also support ray tracing.

Not surprisingly, demand for the RTX 3080 has eclipsed supply. There were also some initial stability concerns with the new GPUs, though updated drivers appear to have ironed out the jitters (see: Tech Talk, page 13). The only remaining question: Can AMD's RX 6900 XT pull off the upset here? We won't know for another month or two, but AMD looks like the underdog.

Right now, Ampere and the RTX 3080 are nailing completions and racking up wins over established veterans, with nary a dropped pass or fumble. If you want the fastest graphics card for the coming year, right now the 3080 is the frontrunner. Sure, the 3090 will put up even more impressive numbers, but it's really a Titan RTX replacement (stay tuned for our review next month). **–JARRED WALTON**

VERDICT
9
KICK ASS!

Nvidia GeForce RTX 3080

+ SUPER BOWL Fastest GPU; major architectural improvements; impressive cooler.

− INJURY REPORT Significant power increases; availability; initial launch driver woes.

$699 www.nvidia.com

GPU BENCHMARKS

	Nvidia GeForce RTX 3080 FE	Nvidia GeForce RTX 2080 Ti
Borderlands 3 (Min/Avg fps)	**58/67**	42/47
Tom Clancy's The Division 2 (Min/Avg fps)	**63/74**	47/55
Far Cry 5 (Min/Avg fps)	**82/97**	66/77
Final Fantasy XIV (Min/Avg fps)	**55/108**	42/85
Red Dead Redemption 2 (Min/Avg fps)	**63/75**	48/57
Shadow of the Tomb Raider (Min/Avg fps)	**69/84**	53/65
Strange Brigade (Min/Avg fps)	**133/156**	98/114

All testing conducted with Core i9-9900K, MSI MEG Z390 ACE, 2x16GB DDR4-3200 CL16, 2TB XPG 8200 Pro M.2 SSD, Seasonic Focus G 850W. Scores are at 4K ultra and show 'minimum' 99th percentile frametime fps and average fps. Best scores are in bold (yeah, that's the 3080 column).

SPECIFICATIONS

GPU / Architecture	GA102 / Ampere
Lithography	Samsung 8N
Core / Boost Clock	1,440 / 1,815 MHz
Memory	10 GB GDDR6X
GPU Cores	8,704
Single Precision	31.59 TFLOPS
TDP	320W
Display Connectors	HDMI 2.1, DisplayPort 1.4a

RTX 3080
GEFORCE RTX

Guess who was late to the photoshoot this issue?

The biggest price we ever did see.

Asus ROG Maximus XII Extreme

Aint no kill quite like overkill

IT'S FAIR TO SAY that the wind has certainly been taken out of the sails of Intel's latest chipset and processors. In fact, at the time of writing, it's been four months since it launched those 10-series CPUs, and it feels like a eternity ago.

That said, even when it launched, Z490 was a bit underwhelming. Although many boards supported PCIe 4.0 by default (something AMD has had since July 2019), the processors themselves don't. What's worse, that connection standard is not something we'll even see from Team Blue until Q1 2021 with the launch of its Rocket Lake processors, which are effectively just a backported variant of its 10nm Willow Cove architecture manufactured on that seemingly interminable 14nm++++ process.

Given 4th-gen Ryzen's debut just this month, and its reported 25 percent IPC performance increase, we wouldn't be surprised to see Intel push the launch of its Rocket Lake processors to the very forefront of 2021—perhaps with a January/February launch. If that happens, that gives the 10-series desktop lineup a grand time on the shelf of around nine months. In fact, it's almost the same amount of time we saw with Intel's 5th-gen consumer processors (Broadwell), before they were replaced by the late, great 6th-gen Skylake architecture—an architecture that all these chips are still based on to this day. The only difference is that Intel no longer has the market dominance it once did. So is it worth buying an expensive Z490 motherboard if the shelf life is potentially so limited? After all, we don't have a guarantee that those 11th-gen Rocket Lake parts will be backwards compatible (but you'd hope).

Well, that's a good question. The Asus ROG Maximus XII Extreme comes in at an eye-watering $743 at the time of writing. That is an astonishing amount for a motherboard, and something you typically see in the realm of professional parts. What do you get for such a hefty outlay? Well there's a teamed 16-phase power setup (each stage capable of tolerating up to 90 amps for a total of 1,440A), fed by twin eight-pin EPS "cooled" cables. You also have support for dual-channel DDR4 memory up to 128GB of RAM with a max frequency reported as 4,800 MHz, and support for up to 4x PCIe 3.0 M.2 slots—two on the board, and two included with an additional add-in card (you can see the slot for that next to the DDR4 slots). There's also enough rear I/O on board to power the Apollo 11 mission and then some, including 10Gbps Ethernet, 2.5Gbps Ethernet, WiFi 6, and a grand total of 12 USB ports, 10 of them being variants of USB 3.2 (two type Cs, and eight Type As in various specs). And then you get the usual frills at this price point, with OLED displays, full "armor" coverings, and unsubtle branding.

As far as performance goes, it is the best board you'll find for getting the absolute limits out of your chip, albeit you won't see that at stock. The problem is, it all depends entirely on your luck in the silicon lottery, and if you're looking at this from an overclocking perspective to enhance your multi-core grunt, you'd arguably be better off waiting for Intel's 11th gen, or hopping over to AMD.

This is an insane enthusiast product, designed for those with limitless budget, or an absolute desire to enter the realm of extreme overclocking, and in a generation that's not likely to last long. Now if Rocket Lake processors are backwards compatible with this (and it's a big if: So far only Gigabyte has said they will be), then great, you've not wasted your investment. But the problem is for that same money you could pick up an equally impressive board for just over $250, with all the aesthetic frills and performance, and then dump the remainder of that cash directly into an Nvidia GeForce RTX 3070 or equivalent, and have change for what this journalist's Kiwi relatives would call a big ol' crate of stubbies.

That puts us in a difficult position, then. On paper, Asus's Maximus XII Extreme is what happens when you throw everything you have into a product. It is impressive, there's no doubt about it. It's the Porsche Taycan Turbo S of the motherboard world. The problem is that it's just massively let down by the surrounding ecosystem, so we can't recommend it because of that.
–ZAK STOREY

VERDICT
7

Asus ROG Maximus XII Extreme

+ GIANT Incredible power delivery system; strong potential overclocking performance; huge I/O setup; 10Gbps port.

− RABBIT Potentially short-lived product; price; price; no seriously the price.

$743 www.asus.com

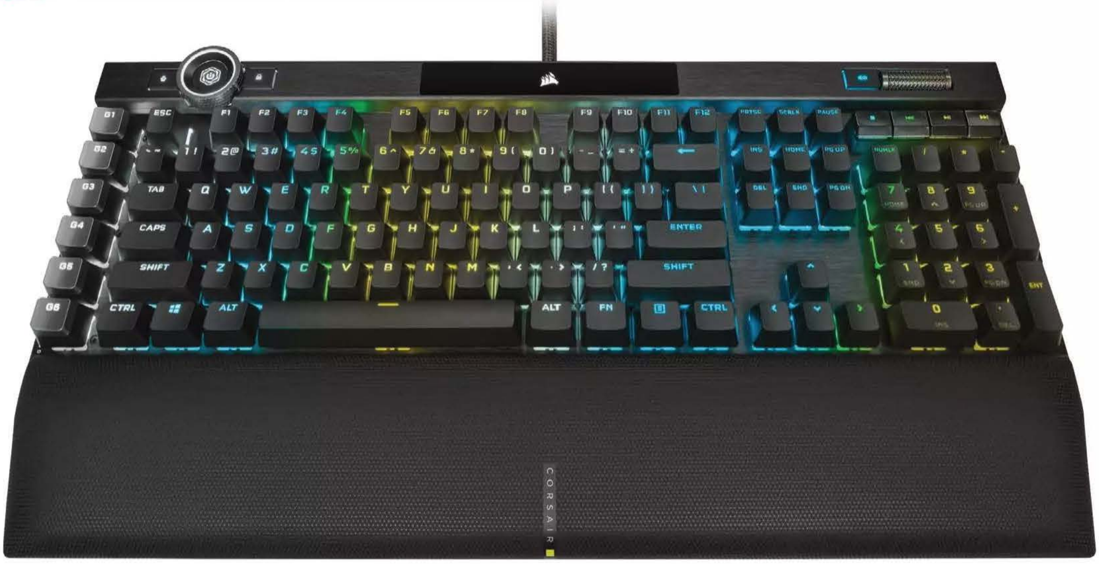
MOTHERBOARD BENCHMARKS

	Asus ROG Maximus XII Extreme	MSI MEG Z490 Ace
TechARP's X264 (Avg fps)	**57.13**	56.25
Cinebench R15 Multi (Index)	**2,632**	2,595
Fry Render (m:s)	**1:14**	1:15
AIDA64 Memory Latency (ns)	**49.8**	50.3
CrystalDisk QD32 Sequential Read (MB/s)	3,278	**3,312**
CrystalDisk QD32 Sequential Write (MB/s)	2,952	**2,972**
Power Draw Idle/Load (Watts)	**52 / 305**	65 / 307
Total War: Warhammer II (fps)	**65**	**65**

Best scores are in bold. Our test bed consists of an Intel Core i9-10900K, 32GB of Corsair Dominator Platinum RGB @ 3600, an Nvidia GeForce RTX 2080 Super, and a 960GB Corsair Force MP510. Total War: Warhammer II was tested at the ultra preset @ 1440p.

SPECIFICATIONS

Chipset / Socket	Z490 / LGA 1200
Max Memory Support	128GB (4x32GB) @ 4800 MHz
Storage Support	4x M.2 PCIe 3.0, 8x SATA
PCIe Support	2x PCIe 3.0 x16, 1x PCIe 3.0 x4
Form Factor	E-ATX (12-inch)
Rear I/O	BIOS Reset, Clear CMOS, 2x USB 2.0 Type A, 8x USB 3.2 Type A, 2x USB 3.2 Type C, 10Gbps Ethernet, 2.5Gbps Ethernet, SPDIF Out, 5.1 Audio



Corsair K100

Reimagining a champion

CORSAIR'S ONE of the few brands out there that really catapulted the mechanical keyboard into the mainstream world of PC gaming. With the launch of its original K70 Vengeance back in 2013, with Cherry MX switches, it was a revolutionary moment.

But the K70 wasn't the only board in Corsair's arsenal. Designed for those who wanted a no-nonsense board with a clean, crisp aluminum design, Cherry MX Red switches, and some kick-ass media controls, including the now-infamous volume scroll wheel, it was in fact a mid-range proposition when it first launched, sitting merrily in the middle of Corsair's stack, between the TKL K60 and the flagship K90. The K90 was a beast of a full-size board, and came with all of the same compliment as the original K70, albeit with a vast bank of macro keys to the left, an untreated brushed metallic aluminum top-plate, and blue LED lighting. Its successor, the K95 RGB, dropped the silver look for a more toned-down brushed black, Corsair's divisive scimitar logo, and updated RGB lighting control. After that came the RGB Platinum, which adjusted the font legends to match the rest of the K-series products, adding an illuminated top-light bar, and shrinking the macro keys down to six. Then finally the XT arrived at the end of 2019, with further refinements to the overall design.

Now Corsair has announced this beauty, the K100, the ultimate successor to the K95 Platinum XT and its predecessors. So what's new here exactly? Is it just another reskin? Well not quite. Available in two separate key-switch types, you can have a Cherry MX Speed, or Corsair's brand new linear switch, the OPX. On top of that it's got the lowest response time we've ever seen from a modern-day keyboard. Thanks to some impressive processing tech, the K100 has a 4,000Hz polling speed, and a latency of just 0.5ms.

Tech aside, you still get that reduced bank of separate macro keys to the left, a smooth new design, dedicated media keys and volume scroll, a USB passthrough, magnetic padded wrist-rest, and interestingly an additional control wheel on the top left. Corsair is calling this the iCUE Control Wheel. Fully customizable in Corsair's Utility Engine, by default it controls backlighting brightness, but you can also rebind it to perform other tasks in applications, such as zoom on Photoshop, or set it up to operate a myriad of streaming commands.

The OPX switch itself is a hybrid mechanical optical design, with an incredibly fast 1.0mm actuation point, paired with specialist Japanese lube, and rated up to 150 million key presses. Compared to an MX Red, it certainly feels quicker both on the depress and rebound, and if you bottom out key presses, the noise is satisfying yet not too overbearing. It's got a slightly different tone to an MX Red but is quieter too. Combined with the double-shot keycaps, it's a very pleasant typing experience overall.

So what are the downsides? Well, this is a flagship product, so it has a flagship price. Regardless of whether you buy the OPX or Cherry MX Speed switch, you're going to be paying out $230. On top of that, we do have some niggles with the control wheel feeling a little unstable; it wiggles when you do use it. And despite Corsair throwing practically the kitchen sink at this thing, there's no sign of those impeccable Capellix LEDs inhabiting any part of it. That's a shame, as the additional brightness and smoothness those things punch out makes some of Corsair's illuminated products the best in the biz.

Ultimately those are minor niggles. For those with deep pockets, the K100 is a fantastic, well-balanced, full-size keyboard for those looking for the very best off-the-shelf mechanical keyboard money can buy. From the redesigned aesthetics to the tech at its heart, this was built from the ground up to be the ultimate flagship. For a board that does everything, it might just be the one. **–ZAK STOREY**

VERDICT

9

Corsair K100

➕ **KOLLOSAL** Impressive new key switch; strong design; response time; program wheel; impressive lighting.

➖ **KONTRIVED** No Capellix LEDs; very pricey; no tactile switch variant.

$230 www.corsair.com

SPECIFICATIONS

Form Factor	Full-size + 6
Switch Type	Corsair OPX Opto-mechanical
Switch Durability	150 Million
Media Keys	Dedicated
Connection Standard	USB 2.0
Battery Life	N/A
Weight	47.62 Oz

© CORSAIR

Pwnage Ultra Custom Wireless

If you want a mouse to match your setup color, look no further

WE HAVE REVIEWED hundreds of peripherals over the years, and we have become rather blasé when we receive them. They are usually so similar it is rare that something really manages to excite us. However, when we received the Pwnage package, we were like kids in a candy shop. Pwnage has been around for some time. It started with an energy drink, then moved to a rather uninspiring mouse, but now it has burst into the market with something remarkably interesting indeed: The Pwnage Ultra Custom Wireless.

As the name suggests, customization is the name of the game for this mouse. You can choose between wireless, wired, battery or no battery, solid or honeycomb plates, and you have a huge number of colors to play with. The base mouse color is always either white or black, but after that, customization is a breeze. The Pwnage website is great to check color combinations: If you want a white mouse with green buttons and a pink solid rear panel, you can have it. If you want a black mouse with yellow buttons and a blue honeycomb back, it is yours. The choice is up to you.

The panels are held in by magnets and can be removed without any tools. The mouse is 2.43oz, but it has been made so that you can remove the battery and save yourself more weight. Removing the battery isn't as easy as it could be. The connector is small, fiddly and in a somewhat hard-to-grip area. We ended up using our long-nosed pliers to ensure that we didn't damage the connector on the PCB or pull out the wires. If you're looking for a wireless mouse, you will need the battery, and if you want to remove the battery, then you can be gentle, remove it and not worry about it again. It is only a big issue if you intend to constantly remove and insert the battery.

The shape of the mouse is familiar, and after a search around we found it to be the same as the Sharkoon Light 2 200. There are some small changes, such as the scroll wheel, and some huge changes, such as the removable wire, the colored covers and, of course, the wireless mode. The mouse is extremely comfortable to use with claw, fingertip, and palm grips—it is a common shape for this very reason—and the PTFE feet enable the mouse to glide well on multiple surfaces.

UNDER COVER

The Omron switches are fantastic to use, and although the LMB and RMB covers can be removed, they are sturdy; it's very impressive. You can also customize the feel of the LMB and RMB by using different spacers, giving yet more customization to this mouse.

Charging is done via a 6.5ft paracord USB-C cable that is of good quality. A small USB dongle and a USB-C adapter is used for the wireless interface. The sensor used is the same as many wireless mice—the Pixart PAW3335 Optical. This is basically the PMW 3360 but uses less power. It performs as would be expected and is an exceptionally good choice of sensor. RGB lighting and the software is extremely limited, but on a wireless mouse more options would mean less battery life. Speaking of battery life, we managed to get around 32 hours of usage out of a 1.2-hour charge. This would be somewhat increased if we turned off the lighting completely.

All in all, then, this is a fantastic mouse in many ways. The color options and customizations are great, and in terms of sensor and comfort it is fantastic too. If it had Qi charging with a surface to match, it would be the best mouse of 2020. As it stands, with the few small issues it has, it is still a very strong contender, and if you do pull the trigger on it, you won't be disappointed. –DAVE ALCOCK

VERDICT
8

Pwnage Ultra Custom Wireless

+ **PWNAGE** fantastic sensor and switches; good battery life; comfortable; a whole host of customization options, from colors to switch spacers.

− **YWNAGE** Battery connector susceptible to damage; limited RGB options; No Qi charging.

$89-$123 www.pwnage.com

SPECIFICATIONS

Sensor Model	Pixart PAW3335 Optical
Max Sensitivity	16,000 CPI
IPS	400
Acceleration	N/A
Programmable Buttons	6
Connection Standard	USB 2.0 – 6 ft
Battery Life	32 hours with lighting, 55 hours basic mode
Weight	2.43 oz with battery, 2.08 oz without battery

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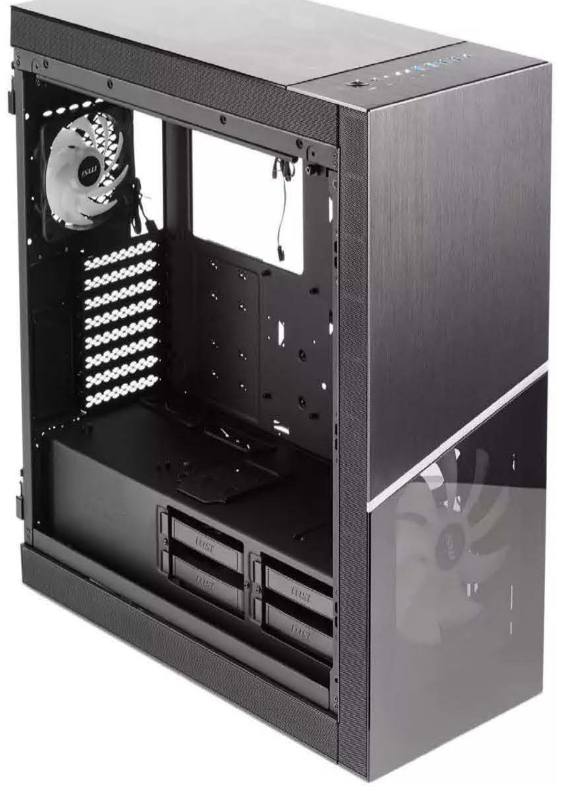
MSI MPG Sekira 500X

Good, but not that original



MSI DOESN'T VENTURE into the world of cases too often, generally making its money from laptops, motherboards, and GPUs. This feels evident in both the marketing material of the MPG Sekira 500X, and the case itself. Visit the product page on MSI's website and you're bombarded with lofty claims that the case was inspired by the "Axe of Perun," accompanied by a bizarre promotional image of a shirtless man gripping what is clearly Gimli's axe from Peter Jackson's *Lord of the Rings* trilogy.

So we didn't really know what to expect from the Sekira 500X, although our initial impressions upon unboxing this beast were good. At first glance, it ticks all the boxes: Toolless tempered-glass panels, integrated RGB lighting, and a slick brushed aluminum finish with a rose-gold trim on the edges and around the front I/O ports. Our other immediate impression was that the Sekira 500X is seriously heavy for a mid-tower case, weighing over 40 pounds.

It's certainly roomy inside, as the hinged glass doors swing open to reveal a spacious E-ATX motherboard cavity and PSU shroud that runs the length of the case. We could've done without the ugly plastic handles on these glass panels, but they do make opening up the case very easy. Five fans come pre-installed (two in the front, two in the roof, one in the rear), four of which are equipped with ARGB lighting while the fifth is plain black, concealed behind the metallic portion of the front plate. A fan hub enables you to tweak lighting modes via a single LED control button on the front I/O; alternatively, you can use a compatible motherboard with MSI's Mystic Light software.

One might expect that so many fans—some of which are large, 200m models—would result in good airflow, but that doesn't appear to be the situation here. Air is drawn in through two thin grilles on either side of the front panel, then expelled through the rear and two similarly narrow vents flanking the glass roof panel. The fans run quietly, but heat management and airflow in general could clearly be better, as the case does little to mitigate running temperatures once a complete system's installed. The rear fan is only a basic 120mm unit, despite the case having room for a 140mm.

FIRST DRAFT

There are a few good ideas at play here, though. In the roof of the case, a radiator bracket sits in a snug slot below the case fans, sliding out easily for quick radiator installation. Our favorite feature is the snap-in plastic drive bays, four of which come pre-fitted in the PSU shroud. These lock into place without tools, and can support either 3.5-inch or 2.5-inch drives. A bracket for mounting additional bays can be purchased separately, as can a PCIe riser for vertical GPU mounting.

Cable management isn't difficult, with Velcro straps and plenty of cutouts for routing cables, but this is a large case, and it doesn't do anything exciting with cable channels or smart tidying solutions. There's nothing interesting to see behind the motherboard mounting plate, just bare screws and drive mounts.

Ultimately, this feels like a decent first draft of an E-ATX case. The construction quality is good, with nothing feeling flimsy or poorly manufactured, and the RGB lighting and design contribute to a solid overall aesthetic. The Sekira 500X needs a second pass, though. That glass-and-metal front panel with its angled slash of RGB lighting might look fantastic, but it hinders airflow and renders the dual 200mm fans somewhat ineffective.

Aside from the airflow issues, the Sekira 500X just isn't very innovative. Easily extractable drive bays and radiator brackets are nice, but it's all stuff we've seen before. Without bringing anything new to the table, this case has to stand on its own merits, and despite being well assembled it struggles to do that. Keep an eye out for a future refinement of the Sekira, perhaps. **–CHRISTIAN GUYTON**

VERDICT 7

MSI MPG Sekira 500X

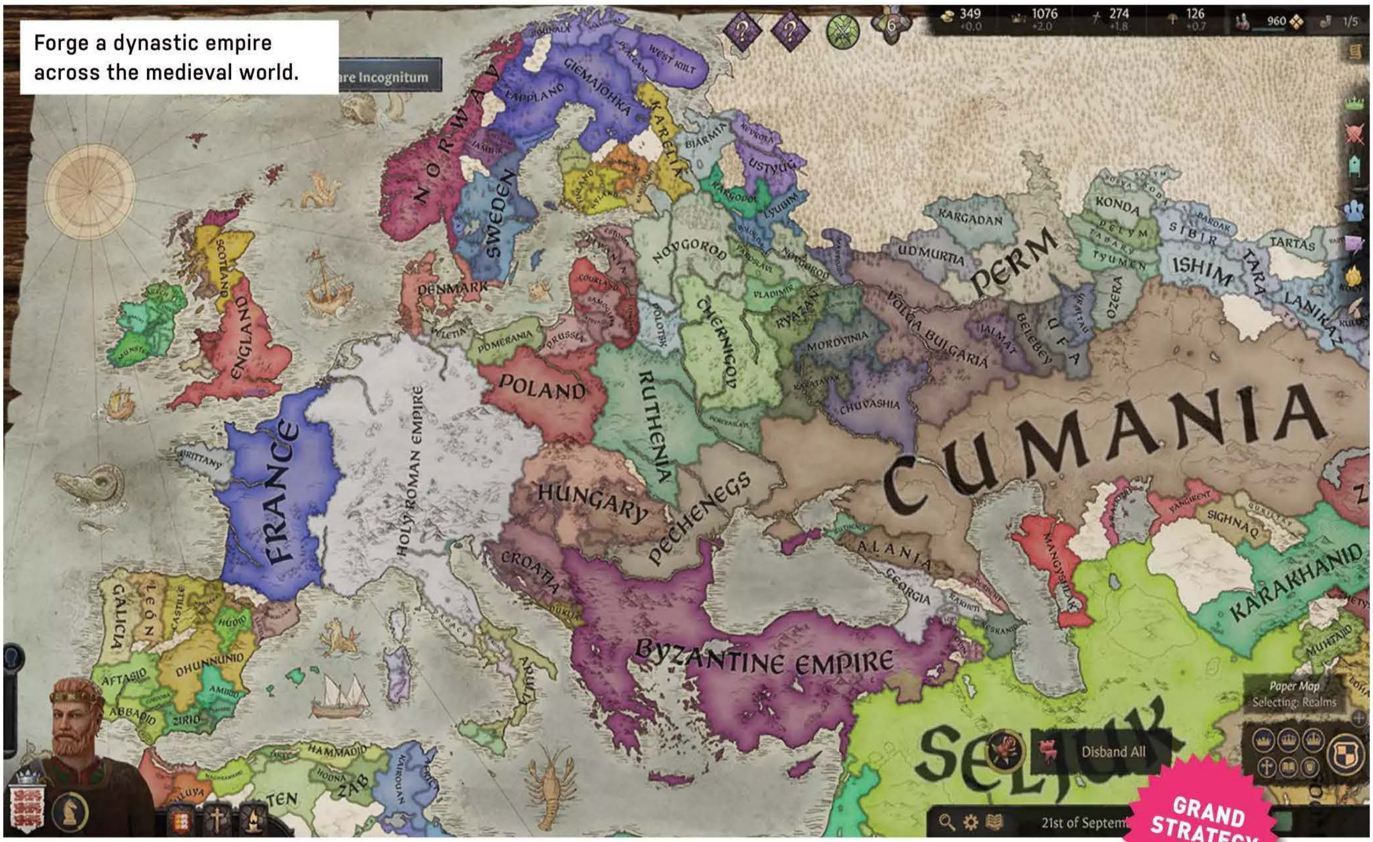
➕ **BATTLEAXE** Very high build quality; good sound damping; lots of drive bays.

➖ **TOOTHPICK** Thermal design needs refining; bulky and heavy; lacks innovation.

$200, msi.com

SPECIFICATIONS

Form Factor	Mid Tower
Motherboard Support	E-ATX, ATX, mATX, ITX
Colors Available	Black
Window Available	Yes
3.5-inch Support	4
2.5-inch Support	3 + 4
Radiator Support	360mm (front), 280mm (top), 140mm (rear)
Fan Support	2 x 200mm (front), 2 x 200mm (top), 1 x 140mm (rear)
Dimensions	9.1 x 20.9 x 21.5 inches
Graphics Card Clearance	15.7 inches
CPU Tower Clearance	6.7 inches
Weight	43.8 lbs



Forge a dynastic empire across the medieval world.

GRAND STRATEGY GAME

Crusader Kings III

The king is dead! Long live the king!

WE NEVER THOUGHT we'd say it, but for once we're thankful for the massive, intrusive, just plain long tutorial that comes with a game. After years of not playing them, of diving into the first mission and decrying it as the game's fault if we couldn't work out what the controls did, both of this month's games have stopped us in our tracks.

What *Crusader Kings III* and *Flight Simulator* have in common it that they're not pick-up-and-play experiences. *Flight Simulator* is an unforgiving simulation of when a large piece of metal intersects with many natural systems. *Crusader Kings* is an unforgiving simulation of a natural system—your family—intersecting with more natural systems and, quite often, multiple large pieces of sharp metal.

Played in the abstract, it's a scrolling map overlaid with pop-up windows filled with detailed stats, text, and a nice line in 3D graphics. You take the role of a medieval noble with a small amount of land to his name, and set about conquering more. The twist is that you're not expected to survive. Your king will succumb to illness, battle, or a sharp piece of metal on a dark night, and be succeeded by his heir. If you're lucky, you've had the time, patience, and ability to groom this heir for power, ushering in a golden age of trade, learning, and expansion. If you're unlucky—say your heir meets with an accident—then you may be succeeded by your lustful, disease-riddled cousin who always hated you and married his sister.

You can only play the hand you're dealt, but you can always try to improve things in the future. Arranging marriages can bring power, money and influence to your house, along with beneficial genetic traits that may, or may not, be passed down to your offspring. Every member of every court in every country seems to hold an opinion on everybody else (this must be exhausting) and raising opinions so that you're universally liked, or feared, is one way of getting on in the world.

Another is to wage war, which sees your armies, represented as a single soldier, step forth to lay siege to enemy cities and knock their armies about. The whole thing is complex enough to make replaying the tutorial a sensible tactical decision, and it's all too easy to get overextended and have an unregarded little ruler from a dusty corner of the continent ride into your capital in an attempt to seize it. After all, he'd always hated you.

For all this, *Crusader Kings III* is as much a game of characters as it is of thrones. There's some rich comedy to be had from occasional pop-ups detailing the sort of deviant antics we always knew aristocrats were capable of. And though your dynasty might be sprawling, the stories it generates feel intimate, giving you just enough detail to whet your imagination's appetite and let it fill in any of the gaps.

With low system requirements but demanding everything from the player, *Crusader Kings III* may not be too obviously different from the previous game in the series, but it's in the refinements, the newly smoothed edges, and the streamlined paths through all those text-filled pop-ups where it finds its majesty. **–IAN EVENDEN**

VERDICT

9

Crusader Kings III

+ RICHARD I Sprawling empire-builder with reams of text and a sharp eye for satire.

– RICHARD III Imposing grand strategy with a lot going on at once, and plenty of reading.

RECOMMENDED SPECS CPU, Ryzen 5 2400G / i5-4670K. RAM, 8GB. GPU, GTX 1650 / R9 390X.

$50, paradoxplaza.com/crusader-kings-iii, M-rated

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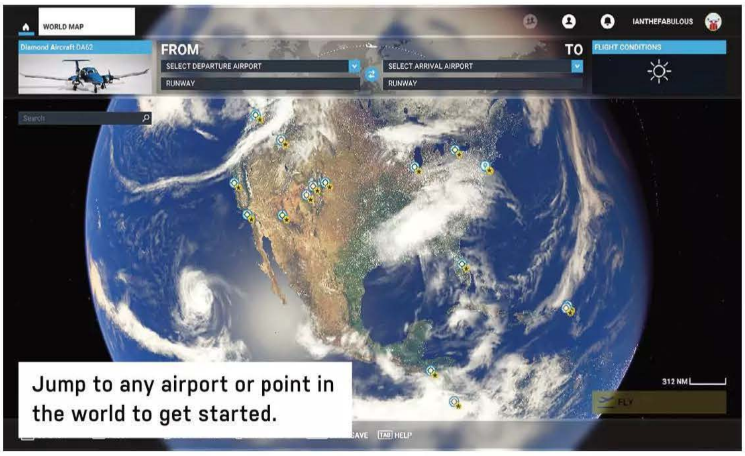
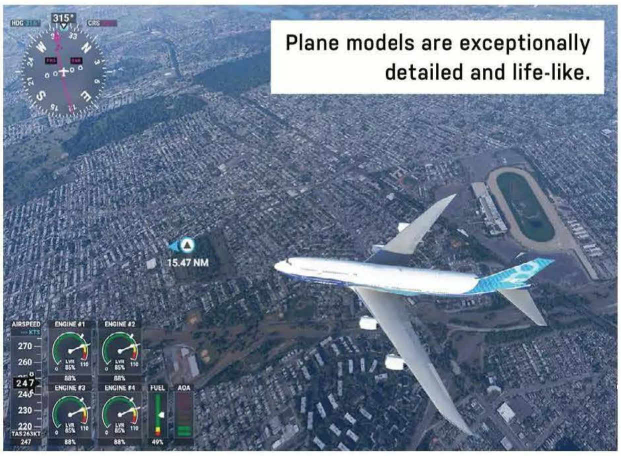
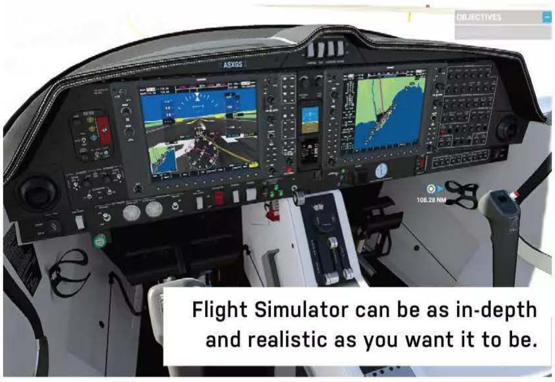


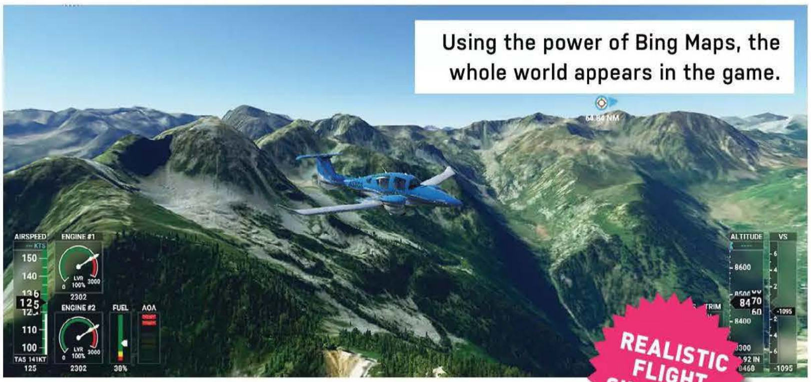
Jump to any airport or point in the world to get started.



Plane models are exceptionally detailed and life-like.



Flight Simulator can be as in-depth and realistic as you want it to be.



Using the power of Bing Maps, the whole world appears in the game.

REALISTIC FLIGHT SIMULATOR

Microsoft Flight Simulator

No snakes on these planes

ELEVEN GAMES into a series that began in 1982 (and has its roots in 1976), and Microsoft has struck absolute gold. More of a hobby in itself than a game, *Flight Simulator* scratches the dream of flight that's itched at the back of your skull since you first saw a huge passenger jet lumber into the air from the freeway near LAX.

All this comes with a price, however. Firstly there's the financial one—the game is available on Game Pass, but if you want the version with the most planes out of the box rather than as add-on DLC you're looking at over $100. Then there's hardware, with it shredding all currently available CPU/GPU combos at the time of writing, especially when over large cities or landing at international airports. It'll be interesting to see how it bears up with an RTX 3080 purring away under the hood, but this is definitely an experience built with future hardware in mind. Then there's the time cost—the initial 500MB client download goes by agreeably fast, but on running that you're treated to a static screen while it downloads 90GB of data. Load times are long too, with our SATA SSD installation taking several minutes to get from menu to cockpit.

But all the waiting is worth it. The incredible technology that pulls live weather data, air traffic control chatter, landscapes and towns generated from Bing Maps data, and then simulates over 1,000 surfaces on the aircraft that's plowing through the middle of it all is a lot for a PC and an internet connection,to handle, but what you get is a game with something for everyone. Everyone who wants to fly, anyway. If you want to manually carry out pre-flight checks then taxi your jumbo for 15 minutes just to get to the runway, you can do that. If you'd rather pop into existence in a twin-prop on a sunny day over the mountain range of your choice, you can do that too. Buzz your house in a red biplane? Yep—though don't expect your home to be there in perfect detail, as there are a lot of generic buildings in small towns, and even some famous city skylines aren't quite as we remember them, awaiting the hand of a modder to bring them to realistic life.

There's another type of hardware we need to address too, the sort that sits on your desk and takes some explaining when you bring a date home. While it's possible to play *Flight Simulator* with an Xbox pad and keyboard combo, the game is better experienced with something like Logitech's Pro Flight Yoke, as this matches the controls in the majority of small planes. There are various options, including Thrustmaster's HOTAS system that couples a fighter plane-style stick with a manual throttle and a lot of buttons.

Whatever control system you're comfortable with, however, *Flight Simulator* remains one of the very best ways to pass an afternoon with your PC. Whether listening to the soothing voice of the tutorial instructor, looking down from the clouds during a solo flight, or approaching a runway with 600 passengers in the rear, it's a game that, without conflict or stress beyond takeoff and landing, challenges both what it means to be a game, and our sense of timekeeping, as long afternoons melt into evenings spent just revelling in the thrill of flight. **–IAN EVENDEN**

VERDICT
9

Microsoft Flight Simulator

+ **LEVEL FLIGHT** Gorgeous graphics; exhilarating simulation.

− **STALL WARNING** Heavy on the hardware specs and downloads.

RECOMMENDED SPECS CPU, Ryzen 7 Pro 2700X / i7-9800X. RAM, 32GB. GPU, RTX 2080 / Radeon VII.

From $60, www.microsoft.com, Rated E

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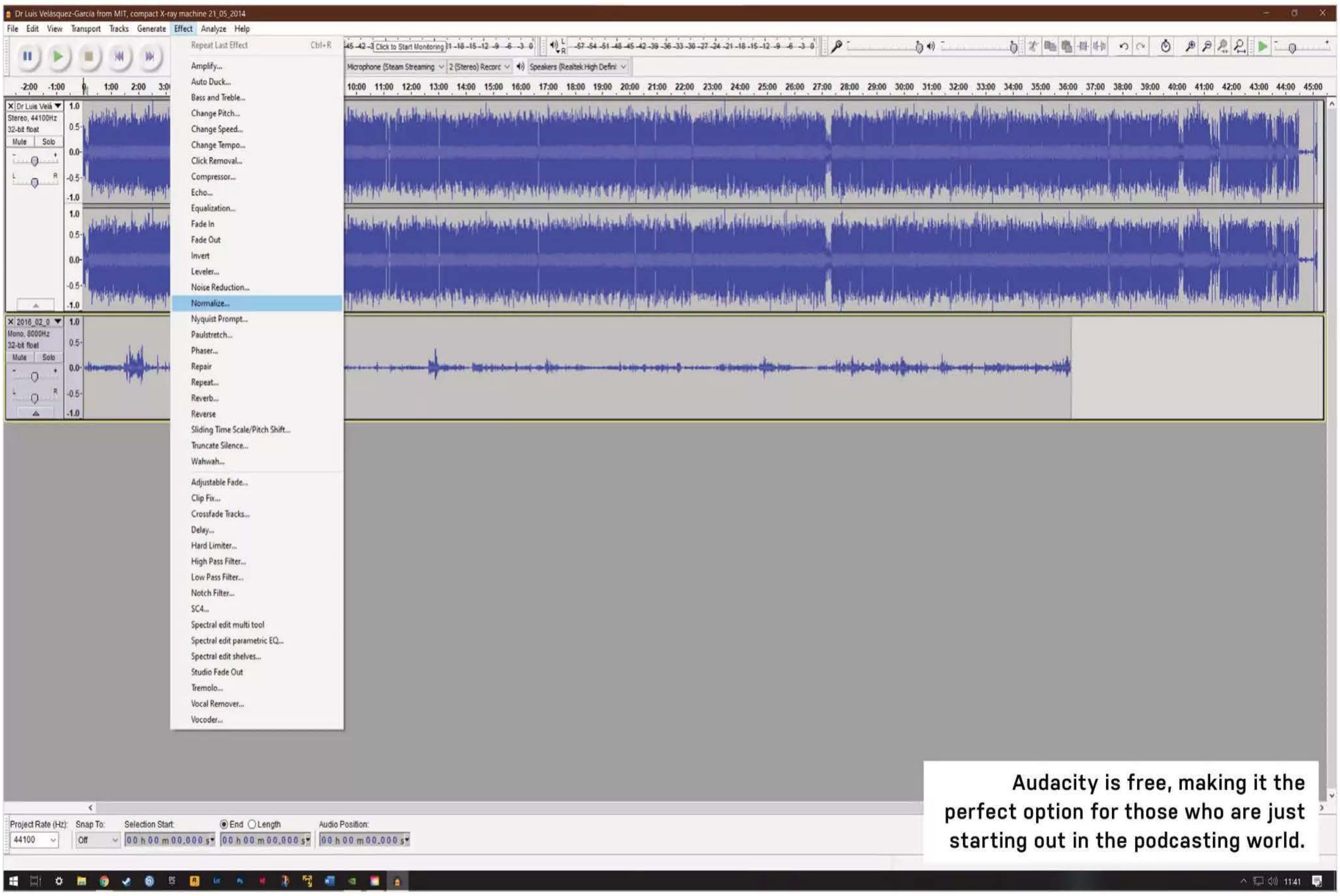
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Spectral edit shelves...
Studio Fade Out
Tremolo...
Vocal Remover...
Vocoder...
Project Rate (Hz):
44100
Snap To:
Off
Selection Start:
End
Length
Audio Position:

Audacity is free, making it the perfect option for those who are just starting out in the podcasting world.

Audacity vs Audition

Battle of the digital audio workshops

PODCASTS, EH? We've heard of them. If you're going to start recording your thoughts for posterity and the amusement of your friends, then you're going to need a couple of things. First is a decent microphone or two, of which there are many out there from brands such as RØDE, Blue, Shure, and Audio-technica. Then you are going to need software to record your podcast and edit it into shape.

There are as many applications made to help with podcasts as there are microphones and subjects to discuss. We're going to look at two of them here: Audacity, which is a free app created by a team of volunteers and released under the GNU General Public License; and Audition, which is part of Adobe's Creative Cloud and therefore comes with all the benefits and pitfalls of commercially developed software—and the Creative Cloud license in particular, which we've discussed before.

Adobe often has a slight advantage when it comes to choosing software because of the dominant position it holds within the creative industry. People who are subscribers to something like Photoshop default to the Adobe solution, but there's a flourishing ecosystem of free software just an online seach away.

That's where Audacity comes in. Both apps are multi-track audio recorders with editing functions, but where Audition is focused on podcast creation, Audacity attempts to be a bit more of a general-purpose audio solution. Audition has the big bucks behind it, so there's something more polished about its interface, whereas selecting your mic input and beginning to record in Audacity is simplicity itself. The free app also enables you to import an existing recording and record a new track alongside it, as well as starting new tracks automatically when you stop recording and start again. In Audition, you need to choose multi-track recording from the toolbar. Audition does, however, make it easier to record the input from different microphones onto different tracks simultaneously—something that's not impossible in Audacity, though it depends on driver support. If you're recording a round-table discussion with multiple mics and participants, Audition is the way to go, as you'll find mixing and editing much easier later on.

Audition also shows stronger performance than Audacity when it comes to actually putting your podcast episode together. Adobe's app uses a non-destructive editing approach similar to its video-editing programs, which means you can always go back to the media bin and replay bits of tape you'd already cut out. The downside of this is larger file sizes, but modern hard drives should have no problem coping. Audacity offers the option of creating copies of your recordings before you start to edit, which you always should, but it remains that you are editing in a destructive manner, with no way of getting back cut tape without using the unlimited undo and redo, or re-importing the audio from backups as a new track.

Mixing, particularly the equalization, limiting, and normalization processes used to ensure that your various speakers sound like they were recorded in the same room at the same time even if they weren't, is portrayed using a skeuomorphic mixing desk metaphor

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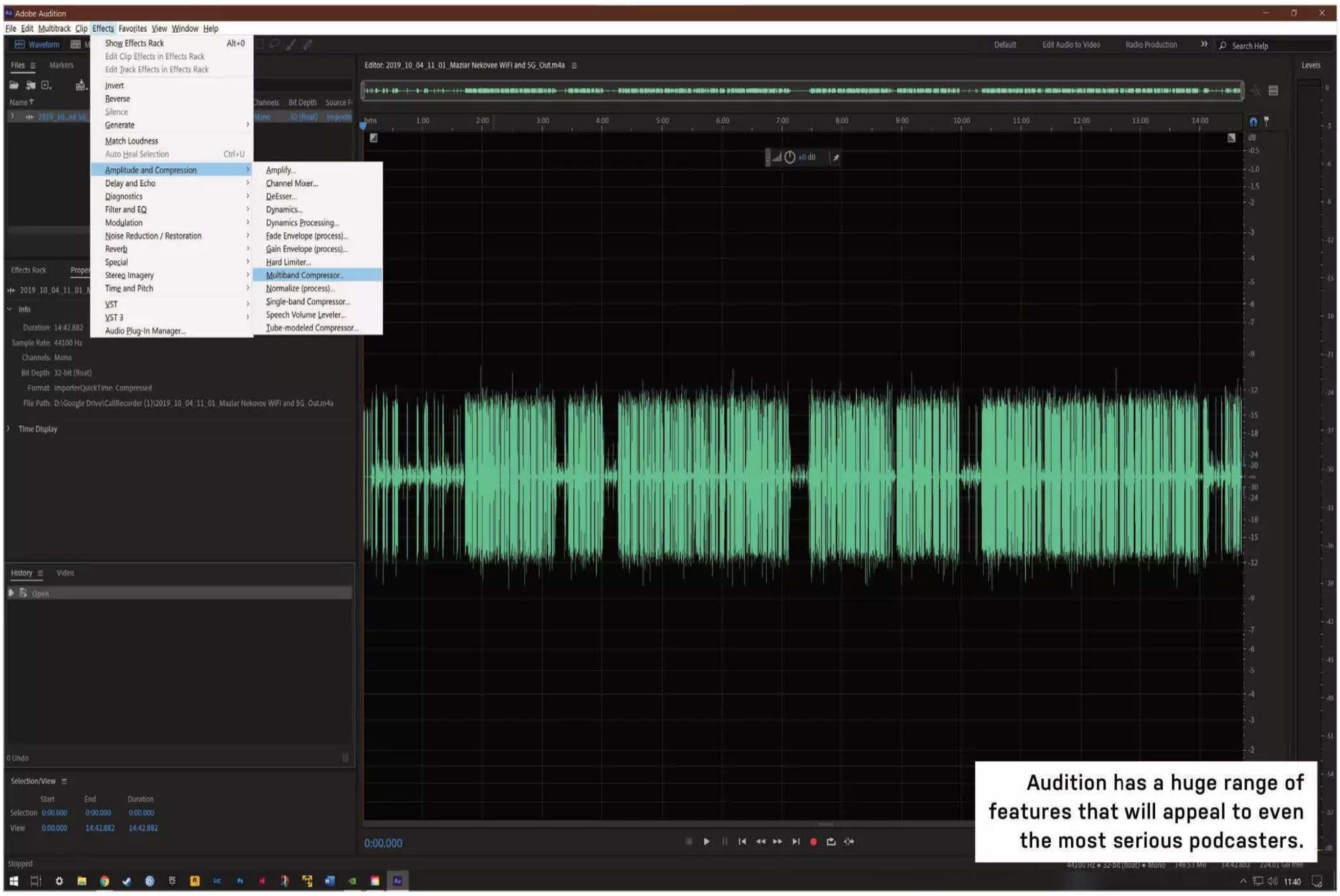
Adobe Audition
File Edit Multitrack Clip Effects Favorites View Window Help
Show Effects Rack
Edit Clip Effects in Effects Rack
Edit Track Effects in Effects Rack
Invert
Reverse
Silence
Generate
Match Loudness
Auto Heal Selection
Amplitude and Compression
Delay and Echo
Diagnostics
Filter and EQ
Modulation
Noise Reduction / Restoration
Reverb
Special
Stereo Imagery
Time and Pitch
VST
VST 3
Audio Plug-In Manager...
Amplify...
Channel Mixer...
DeEsser...
Dynamics...
Dynamics Processing...
Fade Envelope (process)...
Gain Envelope (process)...
Hard Limiter...
Multiband Compressor...
Normalize (process)...
Single-band Compressor...
Speech Volume Leveler...
Tube-modeled Compressor...
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Audition has a huge range of features that will appeal to even the most serious podcasters.

in both apps, with Audacity showing a waveform that represents your audio, with a number of sliders underneath to adjust the tone. Audition's interface is roughly the same, but it dispenses with the waveform. There are presets in both apps, and Audition's are probably more useful than Audacity's—those in the latter app are aimed at recreating the sounds of voices on the telephone or broadcast on radio.

Normalization, the process of limiting the volume of the loudest parts of multiple tracks so they sound more alike, sees both apps take a similar approach, with a hard limiter that clips the peaks at a resolution of 1/10th of a decibel. Audition's is easier to use than Audacity's, however, and the same is true of noise reduction, which cuts out any hiss in the background. Both apps can take a few seconds of silent recording and subtract this from the main tracks, but Audition has a clever adaptive system that analyzes files for a better result.

BIG BOOTS, SMALL FOOTPRINT

A great thing about Audacity is that it's very light in terms of hardware footprint. While Audition will only run on a 64-bit version of Windows 10 with a 1080p display, Audacity only seems to care that your PC's power button works—there's a legacy version for CPUs that don't support the Pentium 4's SSE2 extensions—and also runs nicely on a Raspberry Pi.

We always get to a point, when comparing free software to a commercial competitor, where we point to the paymentless option and say "it's free, you lose nothing, just try it out," and that's exactly what you should do with Audacity. It benefits from a long development history, and its interface is one of the best too. If your needs are simple, then Audacity will do what you want, and do it well. We came across a Reddit thread in which one user admitted to using Audacity to record, and Audition to mix and edit, as that's where the apps' different strengths lay. Audacity is simpler, and what it lacks in options it makes up for with a clearer interface.

If Audacity can do something, Audition probably does it too, only slightly better. There are features that are exclusive to the Adobe app, as you'd expect for something you pay a monthly fee for (one of which is exporting as an MP3 file, which Audacity doesn't support without the installation of an external encoder). Podcasting is a democratic medium, which has allowed many people with nothing but a laptop and mic, or even a cellphone, to broadcast to the world. Within this structure, an app like Audacity makes sense—its free nature is at one with the podcasting world.

If you're doing it all day, every day, as a producer for a large stable of podcasts, then something like Audition absolutely makes sense. But if you're only just starting out, then there's no reason you can't start and hone your production skills with free software before stepping up later. **–IAN EVENDEN**

VERDICT 8

Audacity

+ PAVAROTTI Free; multi-track audio editor perfect for podcasts and any recording.

– WILL.I.AM Destructive editing process; no native MP3 output.

RECOMMENDED SPECS Minimum: 2GB RAM and a 2GHz processor. Recommended: 4GB RAM and 4GHz processor.

$FREE www.audacityteam.org

VERDICT 9

Adobe Audition

+ DAFT PUNK Streamlined and polished interface; non-destructive editing; built for podcasts.

– METAL MACHINE MUSIC No MIDI; Creative Cloud still divisive.

RECOMMENDED SPECS Multicore processor with 64-bit support, 4GB of RAM, 4GB of available hard-disk space for installation.

$21 per month www.adobe.com

© ADOBE AUDITION

LAB NOTES

ZAK STOREY, EDITOR

Please Stop Crashing Into Me

Toying with the idea of moving to more modern vehicles

I COME FROM A GASOLINE-guzzling family. Mom's side is obsessed with classic American cars and V8s, and Pop's was always tinkering around with old-school Volkswagens. Growing up, I was surrounded by engines and noise.

Because of that and my love of technology, my taste in cars is somewhat eclectic. At the moment I have two. My main daily driver is an 07 Audi TT Coupe with a 3.2L V6 engine, and I also have a little 2010 Fiat 500 1.2L 4-cylinder, which the other half drives to work. Both amazing cars, but both somewhat technologically agnostic. I had a Golf Mk7 GTI before this with all the bells and whistles, but I needed to sell it to split it into two vehicles.

This month we've been involved in two road collisions—one at an intersection, where someone rammed into the side of my TT, and another where a suicidal deer decided it wanted to headbutt the front fender of my fiance's Fiat. On the one hand we've been unlucky, but on the other, neither of us needed any hospital attention, and the cars only suffered cosmetic damage really.

Dear life. Stop crashing into my damn cars! Sincerely, Zak.

But it got me thinking about what I want for my next car. The standard tech-enthusiast response would be some form of electric vehicle. Problem is, a) they're really expensive, and b) well, I really like noisy engines. Volkswagen has announced its latest ID.4, a somewhat budget ($40K, or $32.5K with federal grant) electric SUV crossover thing, with a purported range of 250 miles on a single charge. And it has all the gadgetry I could ever want, including additional safety features (now a priority), and it's larger than both the Fiat and the TT.

There's an AWD variant with more power coming next year, and this may be the environmentally friendly, nippy alternative I've been looking for.

INDUSTRY INSIDER

Competition sure is hotting up around AMD right now, isn't it? The tech giant seems to be fighting a war on two fronts, clashing horns with Intel in the processor market while battling Nvidia in the GPU stakes. And yet, somehow, AMD appears to be doing OK.

CEO Lisa Su has made several appearances to push AMD's new products. The Ryzen 5000 series seems poised to finally bring the fight to Intel in the gaming arena, with multiple desktop chips announced going all the way up to a beastly 32-thread 5950X at $799. "Gaming begins with AMD," Su said in an October briefing, and I'm hoping that those words ring true, because AMD doesn't seem to be abandoning its ultra-competitive pricing strategy.

Elsewhere, AMD took a quiet back seat as Nvidia hogged the limelight with its RTX 3000 GPUs (which are staggeringly good), but once the initial furore was over, Team Red struck back with a fresh tease of the upcoming RX 6000 cards. 4K gaming at 60+ fps was the order of the day, so it seems that AMD are finally willing to go on the offensive with direct competitors to Nvidia's flagship cards.

It's a relief to see after almost two years without a true high-end GPU from AMD. The company is undeniably the one to watch right now.

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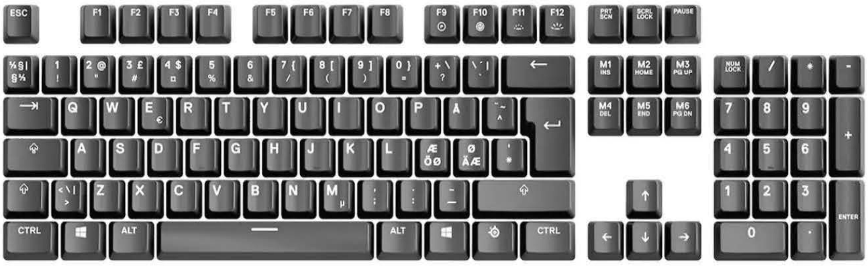

Steelseries Nordic Keycap Set

OH HERE HE GOES AGAIN, talking about languages, when will it end? I know, I know, I've spoken so much about this over the last few issues, I promise this is the last time I do it. Maybe…

Problem is, it's such a big thing for me right now, and it's a huge motivator. It keeps me busy, distracted, and well, if I'm honest, fairly sane. There's only so much *Cobra Kai* you can watch without a karate school nearby (Miyagi-Do forever!). And let's face it, I'm being productive despite being stuck indoors, so that's a plus. The thing is, I now spend so much of my time pouring over Norwegian, aiming towards that end goal of becoming fluent in another language that it's starting to leak into other areas of my life as well. Namely computing.

Last issue, I spoke about using Duolingo to begin my language-learning journey. Couple that with a pronunciation dictionary in Forvo, and an extensive armada of Google Docs at my disposal, and it's all coming together.

There is, however, one thing that's frustrated me, and that's the special characters that are found in Norwegian. As a language, it mostly follows the Roman alphabet, but there are a few Nordic characters they use. Ø, Æ, Å are the ones that come up most often. What I was doing to get around my note-taking problems was literally copying the character I was using most at that time, and pasting it into my documents, sentences, and words. That has some serious problems. Firstly you have to be perpetually aware of what's on your paste-board, and you then have to go back and grab the other characters you need if you swap to using another. It's seriously slow, which is less than useful in timed training to get up a leaderboard (I'm a sucker for a chart with my name on it).

So I got in touch with SteelSeries' PR and got them to send me a set of Nordic keycaps for use on the Apex series. One problem though—the Nordics use an ISO layout, but the review sample I use for my daily driver (the SteelSeries Apex 7) is in ANSI. Another delivery later and I'm finally set up with my own Apex 7 Cherry MX Red, with Nordic Keycaps, in a slightly different layout. A quick dive into Windows' language settings, and I can swap, on the fly, between English and Norsk (bokmål) as and when I need to. It's seamless, and fairly intuitive. You can keep English as the system language, yet still swap to Norsk for your keyboard layout only.

GEEK TESTED & APPROVED

The difference is huge. It's so much more intuitive than before; just dropping the characters in is immensely satisfying. There's been a few hurdles to get past—certain keys are now in different locations, most notably the speech mark, apostrophe, question mark, parentheses, hyphen, and back-slash keys—and certain characters are acquired via the Alt key acting as a modifier, including $ and the @ symbol, but on the whole it's an enjoyable experience, and I'm slowly adjusting to the different layout, though this'll take longer. I could've managed all this by memorizing the Alt+number codes for the special characters, but where's the fun in that? **–ZS**

$15, https://steelseries.com

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EDITOR'S PICK

Christian Guyton,
Staff Writer

VOID B******S

Medieval fantasy platformer *Rogue Legacy* was the first game to sucker me into the roguelike genre, that addictive cycle of venturing forth, dying horribly, then venturing forth again, equipped with better tools and knowledge. I love the formula, and *Rogue Legacy* holds a special place in my heart.

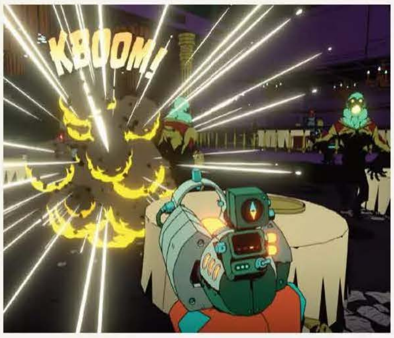
A roguelike isn't necessarily a slashy platformer, though. It's a genre within itself, but one that sits parallel to a game's immediately discernible genre. *Slay the Spire* is a roguelike, but it's a card-based battler first. *FTL: Faster Than Light* from the excellent Subset Games blends roguelike elements seamlessly with real-time strategy.

Void Bastards is the latest roguelike to hook me. A shooter set in a dystopian sci-fi universe with British-imperialistic influences, it places you in the boots of a series of convicts on a stranded prison ship, released one at a time to try to gather the resources needed to get the vessel home.

You do this by exploring defunct spacecraft and space stations, gathering food, fuel, and junk. The locals aren't friendly: Pirates pursue you, while nebula-corrupted janitors and office employees spawn from rifts and assault you with energy attacks and poorly crafted insults. Should you die, you lose the contents of your current inventory, and the prison ship's AI will release a new prisoner to take over.

There's an irreverent humor running through the game. It pairs this with a cartoonish visual style and a core gameplay loop that I found incredibly addictive. Chucking a robot cat packed with cluster bombs into a room of enemies, then locking the door and listening to the carnage never gets old.

$30, steam.com



LETTERS

WE TACKLE TOUGH READER QUESTIONS ON...

> Where Do The Builds Go?
> Car Seat PC Cooling
> Media Servers

What Happens To The Builds?

Hi there, what happens to all of these builds you do after they've been featured in the magazine? **–Various**

EDITOR ZAK STOREY RESPONDS: This is actually a fairly complicated question that we get quite a lot, so I wanted to take the time to respond to all of you who have asked about it. Here at *Maximum PC*, we don't necessarily operate in the same way as, say, a bigger YouTube channel would, or a website. Because we have a more specialist, print-oriented audience, some companies don't deal with us in the same way as they would with an online brand (which sucks).

What that means is a lot of the bigger online publications hold on to all of the kit on a permanent basis. They're typically known as first-wave media—they get the first wave of review samples to meet NDAs, and generally get to hold onto them for future use/testing/whatever. That's speaking from experience and my time at *Tom's Hardware*, and is often why we pair content up with some of our sister titles, such as *TechRadar* or *Tom's Hardware*—that way we have a higher chance of getting parts in permanently (it's also a big reason why I'm pushing to get the *Maximum PC* website and YouTube channel back online).

In our case at the mag, we're sort of second-wave media, but with a few exceptions. So typically when it comes to planning a feature build, we'll come up with the concept, develop a parts list, request the parts in (including swapping components out if our request is denied, ignored, or not possible), build the machine and photograph it, test it, then strip the entire thing down. I'd say around 95 percent of all builds are stripped. This is so we can reuse the parts elsewhere in other systems, review them, or send them back to the PRs to send on to other media. Usually 40 to 50 percent of parts are returned to the manufacturer.

There are a few exceptions to returns, however. Pretty much all cases stay with us. That's because they're difficult and expensive to ship without damaging them, and the build process often scratches or damages the chassis. On top of that, memory, power supplies, cooling, and storage also stay with us about 60 percent of the time, and we also often have a permanent set of current-gen processors from both brands, and sometimes graphics cards as well—at least the flagship ones (getting budget parts in is a nightmare) that stay in house for repeated use.

On top of that, some manufacturers will leave parts on a permanent basis anyway, but that depends on how big the company is, and how large their marketing budget is as well. Regardless, we always consider ourselves caretakers of these products. We certainly don't own them; they remain the property of the manufacturer in question, and if they request them back we return them.

So for returns, typically monitors go back, some processors, motherboards, after-market graphics cards, laptops, pre-built PCs, some headphones and speaker systems go, and that's about it.

There is one exception to all of this, however, and that's when it comes to building liquid-cooled systems. Most of the time, if you build a system with a custom loop in it, all those parts will stay in house forever, as PRs don't want to send a product that's potentially been exposed to coolant to another journalist. It's also a nightmare to strip a rig like that down, and they understand that. They also know all this when they send those parts to begin with, so it's not some big secret, and most PRs or companies will "write-off" those parts once they've got the coverage from it (good or bad).

We of course hold on to some builds to do our day jobs and testing, and typically anything that's older than two to three years we recycle internally at Future with our IT department, who reuse it in video-editing machines or in-house gaming PCs for other brands and publications.

So it's a whole mixed bag, depending on the relationship with the company in question, and a positive minefield to traverse. Hopefully one day we'll be able to give some of these rigs away—or at least, if my grand plans come to fruition we will anyway.

Custom Seat PC Cooling?

Hello, I have been a Ford dealer technician for over 37 years, and a PC enthusiast for a couple of decades.

I recently read the articles about PC cooling, and am curious if anyone has used a

↘ submit your questions to: comments@maximumpc.com thermal electric device (TED) in a PC cooling solution? I'm talking about the devices used in heated/cooled seats in newer vehicles. **–Scott. O**

EDITOR ZAK STOREY RESPONDS: I love questions like this, because they really make you think. I'll be honest, I had absolutely no idea that's how cooled car seats work. It's certainly been an interesting hour or two reading up on this.

To be absolutely blunt, no I don't think anyone has tried this. I'm assuming this would work via the Peltier effect, which is a really cool idea (no pun intended). Although looking at some of the designs for modern-day systems it seems they use both a thermoelectric device coupled with conditioned and channelled air to create the cooling effect. The thing with most forms of modern cooling is that the system is designed to effectively pull heat away from the processor or chip, and then redistribute that in the surrounding air, or out through a radiator itself. That said, things like LN2 do apply pure cooling directly to the processor, so theoretically you could apply a TED in that way, although I imagine it wouldn't be anywhere near as efficient. It might make more sense to amplify the cooling through conditioned air.

So perhaps the best solution would be to develop an enclosed system with a TED generator on one side, with fins, then have a fan drive air across that to cool the air, then push that conditioned air down across a heatsink located on top of the CPU to draw the heat out. Sort of like an AIO liquid cooler, but with air instead of liquid, a fan instead of a pump, and a TED instead of a radiator. It'd be a form of heat exchanger effectively, but depending on throughput, there's certainly potential there, although that's beyond my engineering knowledge.

[NOW ONLINE]

HOW TO PROTECT YOUR IDENTITY ONLINE

System HACKED

When Leonardo DiCaprio played famed conman Frank Abagnale, it awakened many to the glamor of the con. In *Catch Me If You Can*, DiCaprio (as Abagnale) cons flight attendants by pretending to be a pilot, his future father-in-law by pretending to be a lawyer, and his own father using a credit card scheme. In essence, the movie showed that identity theft works best when it's believable. Hackers are after you because you're a believable identity. You are real.

Read the full article here: https://bit.ly/3lLfE0B

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The Scientific Method

A lot is being written today on the topic of media coverage of computers. There's been a long-running commentary that may not be balanced or fair in respect to promoting microcomputers now and then. Yet it's the raison d'être of *Maximum PC* to inform its readers what is available, as it should promote the industry inherent in its title. It's true you tell us about Intel's tax and AMD's lack of financial resources, and this may influence buyer's decisions, but should we believe what you write? I tend to do this as your writing staff "tell it like it is." As in your smaller title there is Minimum BS.

In regards to "The Scientific Method" in Oct. 2020 issue I was most pleased to see a high-powered computer not specifically designed for games. Large data systems do have a place in home computing for consumers, and your magazine has recognized this. **–Murray M.**

EDITOR ZAK STOREY RESPONDS: You're very welcome, and thank you for the kind words, it's something we're really working hard on here at the moment. As builds are a big part of why and how I got into PCs to begin with, and in fact perhaps a big part of why I am where I am in my career, I think it'd be foolhardy for me not to appreciate the fact that there are so many folk out there who use PCs for a whole variety of reasons, not just gaming.

Of course, for myself that's primarily what I do (aside from writing and studying), but yeah it's very easy to get sidetracked into it, especially as that's what most of the industry is about right now.

That said, as we've been getting a lot of these emails now, I've decided to push the Turbo build at the back of Blueprints into a more professional workstation going forward. Next issue we're swapping out all three of the cases to more modern choices, and the Turbo build in particular has a full-tower chassis that I want to convert to a more permanent professional setup. That means quad-channel memory at a minimum for both the Intel and AMD builds, sizable storage and memory solutions, and even professional-level graphics card recommendations.

Media Servers?

Glad to see that you're back Zak! I've seen a lot of good changes since you became editor. I really like the expanding types of build and the AMD/Intel builds at the back of the mag. One more build that I'd like to see is a media server build. This one is a little different since it needs A LOT of space for hard drives (15-20+). And it needs the ability to potentially transcode media not supported by the end client. **–Mike B.**

EDITOR ZAK STOREY RESPONDS: Hi Mike, apologies in advance, I know we've cut your email a little short there, that's just because I talk too much, and we can't fit everything on the page because of it. But I have read it, and I want to say thanks as always for the complements. I know my ride so far here hasn't been perfectly smooth, but I'm hoping to learn and continue to make *Maximum PC* better for everyone.

In regards to your query, you'll be glad to know that next issue we've got a full eight-page feature on Jellyfin and its alternatives and why you'll want to use it. But I hear you, there's definitely a lot more to cover here. In fact I was talking to the guys over at *Linux Format* about possibly collaborating on a build very much like this. We've had a few requests in regards to building a system like this, so it's on the cards. I may actually pen this in for our January issue (not next issue, the issue after), although finding a case with that many hot-swappable drives may be a challenge. I worry, given the capacity and size of drives these days, that we might be reaching a point where we're flirting with server racks rather than cases. The biggest I can see is Fractal Design's Define 7 XL Full Tower, which can support up to 18 HDDs, but again no mention of them being hot-swappable on demand,which is somewhat annoying. We'll give this some thought and get back to you, or you'll see in a few issues. ⏻

THE BUILDS

SADLY OUR RESIDENT BLUEPRINTER has had to take some unexpected time off, so it's fallen to el big cheeso here (he was never any good in his Spanish classes) to implement some changes.

So what's been happening? Well in short, major price drops on both our builds, and some significant part shuffles to prepare for our new cases dropping next issue. And it's about time! For our AMD build we've opted to go for the Ryzen 3 3100 quad-core processor. It's a favorite of ours at the moment for budget builds, complete with four cores and eight threads. OK, so it's not about to win any rendering competitions, but only two years ago this was the high-end staple core count for all of us in the consumer market, and it's more than enough for any budget escapades into gaming, or rendering. On the Blue side of the field, we've gone and grabbed one of those shiny new Intel Core i5-10400s. Ever so slightly stockier than our AMD competition, this six-core, 12-thread chip packs a punch, and best of all comes with a cooler as standard straight out of the box.

We've also swapped out the GPUs for something a little more 1080p reasonable. Both cards, AMD and Nvidia, achieve on average 60fps across a myriad of titles at 1080p, making them perfect picks for our new parts list, and on top of that we've also added some shiny upgrades to storage, in the form of a 256GB Samsung 980 Pro PCIe 4.0 drive for the AMD rig and a 256GB XPG SX8100 PCIe 3.0 drive for Intel. AMD still has the upper hand here, and thanks to that Ryzen 3 3100, you can finally take advantage of the new connection standard, unlike with the 3200G and 3400G.

Lastly, we've also swapped out our Linux budget OS for an OEM Windows Home key. You can find this at Kinguin for around $25 or so: Genuine, one-use keys. Although ideally you'll want a permanent license attached to your Microsoft account so you can pull it across from one build to the next.

AMD INGREDIENTS

PART		PRICE
Case	BitFenix Nova TG	$65
PSU	450W Gigabyte GP-450B 80+ Bronze **NEW**	$50
Mobo	ASRock B550M Pro4 **NEW**	$105
CPU	AMD Ryzen 3 3100 **NEW**	$120
GPU	Gigabyte GeForce GTX 1650 Super Windforce OC 4G **NEW**	$170
RAM	16GB (2 x 8GB) GeIL Evo Potenza @ 3,600MT/s **NEW**	$59
SSD	250GB Samsung 980 Pro M.2 PCIe 4.0 **NEW**	$30
HDD	1TB Seagate Constellation ES ST1000NM0001 HDD	$30
OS	Windows 10 Home 64-bit OEM **NEW**	$25

Approximate Price: $654

INTEL INGREDIENTS

PART		PRICE
Case	BitFenix Nova TG	$65
PSU	450W Gigabyte GP-450B 80+ Bronze **NEW**	$50
Mobo	Gigabyte B460M Aorus Pro M-ATX **NEW**	$95
CPU	IIntel Core i5-10400 **NEW**	$180
GPU	Gigabyte Radeon RX 5500 XT 4GB **NEW**	$180
RAM	16GB (2 x 8GB) GeIL Evo Potenza @ 3,600MT/s **NEW**	$59
SSD	256GB XPG SX8100 M.2 PCIe 3.0 SSD **NEW**	$35
HDD	1TB Seagate Constellation ES ST1000NM0001 HDD	$30
OS	Windows 10 Home 64-bit OEM **NEW**	$25

Approximate Price: $719

MID-RANGE

AND THERE GOES THE PLANS to lop off some of the price. We've had to make some serious changes to both our builds this time around, opting for an AMD Ryzen 5 3600X for the AMD build. This is still a meaty six-core, 12-thread chip, with a seriously impressive clock speed and decent gaming and rendering performance too, but it is somewhat shy of the 3700X we had last issue. Sadly there have been price hikes galore (you'd have thought that these things would have dropped in price given AMD's new stuff, but hey ho).

On top of that we've paired it with a bit of a beefier cooler in the form of be quiet!'s Dark Rock 4. Rated to handle chips with a TDP of up to 200W, it will be more than enough to get the most out of that processor.

Aside from that and a tweak to the memory to bring it up to that 3600 MT/s mark for a boost to performance, there's not a lot to report on here. So over to the Intel build we go.

We've still managed to hold onto that eight-core, 16-thread i7-10700 for this issue, but again we've swapped out the cooler for something with a little more style (and a little less beige). We've also stuck with the same graphics card across both builds. Right now, the mid-range GPU arena is in some serious upheaval, and to that end, until the RTX 3070 finally drops next issue, the 5700 is the best-value card out there.

We've also managed to snag a kick-ass deal on a swanky MSI motherboard, dropping the price there by $20, and sunk our teeth into a pretty sweet saving on Western Digital's WD Black SN750 PCIe 3.0 M.2 SSD. It's the only drive we've seen that's been able to give Samsung a run for its money in the 3.0 space, and for $70 for 500GB it makes the perfect OS drive, that's for sure. Combine that with a set of fancy 3200 MT/s memory (because even Intel needs a little memory love every now and then), and you're on the way to one heck of a kick-ass build.

AMD INGREDIENTS

PART			PRICE
Case	Fractal Design Meshify C		$85
PSU	650W Corsair CX650		$85
Mobo	Asus TUF Gaming X570-Plus		$161
CPU	AMD Ryzen 5 3600X	NEW	$240
Cooler	Be quiet! Dark Rock 4 CPU Cooler	NEW	$75
GPU	MSI Radeon RX 5700 MECH GP OC 8GB		$350
RAM	16GB (2 x 8GB) GeIL Evo Potenza @ 3,600MT/s	NEW	$59
SSD	500GB Gigabyte Aorus Gen4 M.2 PCIe 4.0		$100
HDD	1TB Seagate Constellation ES ST1000NM0001 HDD		$30
OS	Windows 10 Home 64-bit OEM		$25
Approximate Price:			**$1,210**

INTEL INGREDIENTS

PART			PRICE
Case	Fractal Design Meshify C		$85
PSU	650W Corsair CX650		$85
Mobo	MSI MPG Z490 Gaming Plus	NEW	$184
CPU	Intel Core i7-10700		$320
Cooler	Noctua NH-U12S chromax.black	NEW	$70
GPU	MSI Radeon RX 5700 MECH GP OC 8GB	NEW	$350
RAM	16GB (2 x 8GB) G.Skill Trident Z RGB @ 3200	NEW	$73
SSD	500GB WD Black SN750 M.2 PCIe 3.0	NEW	$70
HDD	1TB Seagate Constellation ES ST1000NM0001 HDD		$30
OS	Windows 10 Home 64-bit OEM		$25
Approximate Price:			**$1,292**

TURBO

DANG, THAT'S ONE HECK of a price difference between the two builds we have here, that's for sure. We've recalibrated our two systems one last time, before we convert them into far more grandiose platforms for next issue (with the much-heralded new cases, of course).

For our AMD build we've splashed the cash just a touch and gone with a brand new, slightly pricier motherboard in the form of Gigabyte's Aorus Ultra. It's a beast of a board, and Gigabyte has come a long way in the last few years in regards to its BIOS settings, so it's good to see the brand make headway into more premium mobo offerings. On top of that we've opted for a Corsair RM-series power supply, and also splurged on the PCIe 4.0 SSD, replacing our trusty early-adopter drive for the newly released and far more mature Samsung 980 Pro.

And of course, we couldn't leave this issue without going for a decent RTX 3080 graphics card as well. We're using the same card in our Intel build this time around too—MSI's Ventus RTX 3080 tri cooler. By the time you read this the drivers should be more than mature enough to handle the extra clock speeds, and those early-adopter crashes should be a thing of the past. It comes with one caveat of course, which is that right now these cards are pretty much entirely out of stock. Soon, though, Nvidia should have somewhat resolved that, and right now there simply isn't a better card for the coin. If 4K gaming is your thing, then the RTX 3080 is a true king of frame-rendering beauty.

Moving onto our Intel build, and we've kept things resolutely conservative for this issue, but there has been one big change: We dropped that hefty $270 motherboard from last issue, and have instead opted for this stellar board from ASRock. At just over $100 cheaper it gives us a bit of wiggle room to play with for our slight PCIe SSD upgrade. We've also been lucky with the Core i9-10900K too, as it's now $125 cheaper than last issue. All that adds up to a price difference of around $300 or so.

AMD INGREDIENTS

PART		PRICE
Case	NZXT H710i	$150
PSU	750W Corsair RM750x Modular PSU **NEW**	$135
Mobo	Gigabyte X570 Aorus Ultra **NEW**	$290
CPU	AMD Ryzen 9 3950X	$715
Cooler	Corsair iCUE H115i RGB Pro XT 280mm	$140
GPU	MSI GeForce RTX 3080 Ventus 3X 10G **NEW**	$700
RAM	32GB (2 x 16GB) G.Skill TridentZ Neo @ 3600MT/s	$170
SSD	1TB Samsung 980 Pro M.2 PCIe 4.0 **NEW**	$230
HDD	6TB Seagate BarraCuda ST6000DM003	$144
OS	Windows 10 Home 64-bit OEM	$25

Approximate Price: $2,699

INTEL INGREDIENTS

PART		PRICE
Case	NZXT H710i	$150
PSU	850W NZXT C850	$120
Mobo	ASRock Z490 Extreme4 **NEW**	$180
CPU	Intel Core i9-10900K	$700
Cooler	Cooler Master MasterLiquid ML360R ARGB 360mm	$142
GPU	MSI GeForce RTX 3080 Ventus 3X 10G **NEW**	$700
RAM	32GB (2 x 16GB) Corsair Dominator Platinum @ 3000MT/s **NEW**	$168
SSD	1TB WD Black SN750 M.2 PCIe 3.0 **NEW**	$120
HDD	6TB Seagate BarraCuda ST6000DM003	$130
OS	Windows 10 Home 64-bit OEM	$25

Approximate Price: $2,435

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